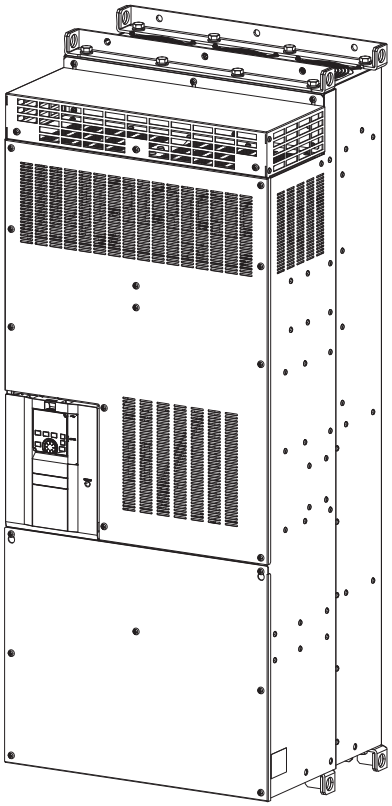
MITSUBISHI ELECTRIC

# INVERTER A800

# FR-A802 (SEPARATED CONVERTER TYPE) INSTRUCTION MANUAL (HARDWARE)

## FR-A842-07700(315K) to 12120(500K)




INTRODUCTION 1

INSTALLATION AND WIRING 2

PRECAUTIONS FOR USE OF THE INVERTER 3

PROTECTIVE FUNCTIONS 4

PRECAUTIONS FOR MAINTENANCE AND INSPECTION 5

SPECIFICATIONS 6

**Thank you for choosing this Mitsubishi inverter.**
**This Instruction Manual describes handling and cautions about the hardware, such as installation and wiring, for the FR-A802 (separated converter type) that are different from the FR-800.**
**Information about the software, such as basic operations and parameters, is described in the FR-A800 Instruction Manual (Detailed) in the CD-ROM enclosed with the product.**
**In addition to this manual, please read the manuals in the enclosed CD-ROM carefully. Do not use this product until you have a full knowledge of the equipment, safety information and instructions.**
**Please forward this Instruction Manual to the end user.**

## Safety Instructions

**Do not attempt to install, operate, maintain or inspect the product until you have read through this Instruction Manual (Detailed) and appended documents carefully and can use the equipment correctly. Do not use this product until you have a full knowledge of the equipment, safety information and instructions.**
**Installation, operation, maintenance and inspection must be performed by qualified personnel. Here, an expert means a person who meets all the conditions below.**
**• A person who took a proper engineering training. Such training may be available at your local Mitsubishi Electric office. Contact your local sales office for schedules and locations.**
**• A person who can access operating manuals for the protective devices (e.g. light curtain) connected to the safety control system. A person who has read and familiarized himself/herself with the manuals.**

**In this Instruction Manual (Detailed), the safety instruction levels are classified into "Warning" and "Caution"**

**⚠Warning** **Incorrect handling may cause hazardous conditions, resulting in death or severe injury.**

**⚠Caution** **Incorrect handling may cause hazardous conditions, resulting in medium or slight injury, or may cause only material damage.**

**The ⚠Caution level may even lead to a serious consequence according to conditions. Both instruction levels must be followed because these are important to personal safety.**

### ◆ Electric Shock Prevention

**⚠Warning**

- While the inverter power is ON, do not open the front cover or the wiring cover. Do not run the inverter with the front cover or the wiring cover removed. Otherwise you may access the exposed high voltage terminals or the charging part of the circuitry and get an electric shock.
- Even if power is OFF, do not remove the front cover except for wiring or periodic inspection. You may accidentally touch the charged inverter circuits and get an electric shock.
- Before wiring or inspection, LED indication of the operation panel must be switched OFF. Any person who is involved in wiring or inspection shall wait for at least 10 minutes after the power supply has been switched OFF and check that there are no residual voltage using a tester or the like. The capacitor is charged with high voltage for some time after power OFF, and it is dangerous.
- This inverter must be earthed (grounded). Earthing (grounding) must conform to the requirements of national and local safety regulations and electrical code (NEC section 250, IEC 536 class 1 and other applicable standards). A neutral-point earthed (grounded) power supply inverter in compliance with EN standard must be used.
- Any person who is involved in wiring or inspection of this equipment shall be fully competent to do the work.
- The inverter must be installed before wiring. Otherwise you may get an electric shock or be injured.
- Setting dial and key operations must be performed with dry hands to prevent an electric shock. Otherwise you may get an electric shock.
- Do not subject the cables to scratches, excessive stress,heavy loads or pinching. Otherwise you may get an electric shock.
- Do not change the cooling fan while power is ON. It is dangerous to change the cooling fan while power is ON.
- Do not touch the printed circuit board or handle the cables with wet hands. Otherwise you may get an electric shock.
- An PM motor is a synchronous motor with high-performance magnets embedded in the rotor. Motor terminals holds high-voltage while the motor is running even after the inverter power is turned OFF. Before wiring or inspection, the motor must be confirmed to be stopped. In an application, such as fan and blower, where the motor is driven by the load, a low-voltage manual motor starter must be connected at the inverter's output side, and wiring and inspection must be performed while the motor starter is open. Otherwise you may get an electric shock.

### ◆ Fire Prevention

**⚠Caution**

- Inverter must be installed on a nonflammable wall without holes (so that nobody touches the inverter heatsink on the rear side, etc.). Mounting it to or near flammable material may cause a fire.
- If the inverter has become faulty, the inverter power must be switched OFF. A continuous flow of large current may cause a fire.
- Be sure to perform daily and periodic inspections as specified in the Instruction Manual. If a product is used without any inspection, a burst, breakage, or a fire may occur.

### ◆ Injury Prevention

**⚠Caution**

- The voltage applied to each terminal must be the ones specified in the Instruction Manual. Otherwise burst, damage, etc. may occur.
- The cables must be connected to the correct terminals. Otherwise burst, damage, etc. may occur.
- The polarity (+ and -) must be correct. Otherwise burst, damage, etc. may occur.
- While power is ON or for some time after power-OFF, do not touch the inverter as it will be extremely hot. Touching these devices may cause a burn.

### ◆ Additional Instructions

**The following instructions must be also followed. If the product is handled incorrectly, it may cause unexpected fault, an injury, or an electric shock.**

**⚠Caution**

**Transportation and Mounting**

- Any person who is opening a package using a sharp object, such as a knife and cutter, must wear gloves to prevent injuries caused by the edge of the sharp object.
- The product must be transported in correct method that corresponds to the weight. Failure to do so may lead to injuries.
- Do not stand or rest heavy objects on the product.
- Do not stack the boxes containing inverters higher than the number recommended.
- When carrying the inverter, do not hold it by the front cover; it may fall off or fail.
- During installation, caution must be taken not to drop the inverter as doing so may cause injuries.
- The product must be installed on the surface that withstands the weight of the inverter.
- Do not install the product on a hot surface.
- The mounting orientation of the inverter must be correct.
- The inverter must be installed on a strong surface securely with screws so that it will not drop.
- Do not install or operate the inverter if it is damaged or has parts missing.
- Foreign conductive objects must be prevented from entering the inverter. That includes screws and metal fragments or other flammable substance such as oil.
- As the inverter is a precision instrument, do not drop or subject it to impact.
- The surrounding air temperature for LD, ND (initial setting), and HD models must be between -10 and +50°C (non-freezing). The surrounding air temperature for SLD must be between -10 and +40°C (non-freezing). Otherwise the inverter may be damaged.
- The ambient humidity must be 95%RH or less (non-condensing). Otherwise the inverter may be damaged. (Refer to page 17 for details.)

## ⚠ Caution

**Transportation and Mounting**

- The storage temperature (applicable for a short time, e.g. during transit) must be between -20 and +65°C. Otherwise the inverter may be damaged.
- The inverter must be used indoors (without corrosive gas, flammable gas, oil mist, dust and dirt etc.) Otherwise the inverter may be damaged.
- The inverter must be used at an altitude of 2500 m or less above sea level, with 2.9 m/s$^2$ or less vibration at 10 to 55 Hz (directions of X, Y, Z axes). Otherwise the inverter may be damaged. (Refer to page 17 for details.)
- If halogen-based materials (fluorine, chlorine, bromine, iodine, etc.) infiltrate into a Mitsubishi product, the product will be damaged. Halogen-based materials are often included in fumigant, which is used to sterilize or disinfest wooden packages. When packaging, prevent residual fumigant components from being infiltrated into Mitsubishi products, or use an alternative sterilization or disinfection method (heat disinfection, etc.) for packaging. Sterilization of disinfection of wooden package should also be performed before packaging the product.

**Wiring**

- Do not install a power factor correction capacitor or surge suppressor/capacitor type filter on the inverter output side. These devices on the inverter output side may be overheated or burn out.
- The output side terminals (terminals U, V, and W) must be connected correctly. Otherwise the motor will rotate inversely.
- PM motor terminals (U, V, W) hold high-voltage while the PM motor is running even after the power is turned OFF. Before wiring, the PM motor must be confirmed to be stopped. Otherwise you may get an electric shock.
- Never connect an PM motor to the commercial power supply. Applying the commercial power supply to input terminals (U,V, W) of an PM motor will burn the PM motor. The PM motor must be connected with the output terminals (U, V, W) of the inverter.

**Trial run**

- Before starting operation, each parameter must be confirmed and adjusted. A failure to do so may cause some machines to make unexpected motions.

## ⚠ Warning

**Usage**

- Everyone must stay away from the equipment when the retry function is set as it will restart suddenly after a trip.
- STOP RESET Since pressing a key may not stop output depending on the function setting status, separate circuit and switch that make an emergency stop (power OFF, mechanical brake operation for emergency stop, etc.) must be provided.
- OFF status of the start signal must be confirmed before resetting the inverter fault. Resetting inverter fault with the start signal ON restarts the motor suddenly.
- Do not use an PM motor for an application where the PM motor is driven by its load and runs at a speed higher than the maximum motor speed.
- Use this inverter only with three-phase induction motors or with an PM motor. Connection of any other electrical equipment to the inverter output may damage the equipment.
- Performing pre-excitation (LX signal and X13 signal) under torque control (Real sensorless vector control) may start the motor running at a low speed even when the start command (STF or STR) is not input The motor may run also at a low speed when the speed limit value = 0 with a start command input. It must be confirmed that the motor running will not cause any safety problem before performing pre-excitation.
- Do not modify the equipment.
- Do not perform parts removal which is not instructed in this manual. Doing so may lead to fault or damage of the product.

## ⚠ Caution

**Usage**

- The electronic thermal relay function does not guarantee protection of the motor from overheating. It is recommended to install both an external thermal and PTC thermistor for overheat protection.
- Do not use a magnetic contactor on the inverter input for frequent starting/stopping of the inverter. Otherwise the life of the inverter decreases.
- The effect of electromagnetic interference must be reduced by using a noise filter or by other means. Otherwise nearby electronic equipment may be affected.
- Appropriate measures must be taken to suppress harmonics. Otherwise power supply harmonics from the inverter may heat/ damage the power factor correction capacitor and generator.
- When driving a 400V class motor by the inverter, the motor must be an insulation-enhanced motor or measures must be taken to suppress surge voltage. Surge voltage attributable to the wiring constants may occur at the motor terminals, deteriorating the insulation of the motor.
- When parameter clear or all parameter clear is performed, the required parameters must be set again before starting operations. because all parameters return to their initial values.
- The inverter can be easily set for high-speed operation. Before changing its setting, the performances of the motor and machine must be fully examined.
- Stop status cannot be hold by the inverter's brake function. In addition to the inverter's brake function, a holding device must be installed to ensure safety.
- Before running an inverter which had been stored for a long period, inspection and test operation must be performed.
- Static electricity in your body must be discharged beforeyou touch the product.
- Only one PM motor can be connected to an inverter.
- An PM motor must be used under PM sensorless vector control. Do not use a synchronous motor, induction motor, or synchronous induction motor.
- Do not connect an PM motor in the induction motor control settings (initial settings). Do not use an induction motor in the PM sensorless vector control settings. It will cause a failure.
- In the system with an PM motor, the inverter power must be turned ON before closing the contacts of the contactor at the output side.

**Emergency stop**

- A safety backup such as an emergency brake must be provided to prevent hazardous conditions to the machine and equipment in case of inverter failure.
- When the breaker on the inverter input side trips, thewiring must be checked for fault (short circuit), and internalparts of the drive unit for a damage, etc. The cause of the trip must be identified and removed before turning ON the power of the breaker.
- When a protective function activates, take an appropriate corrective action, then reset the inverter, and resume the operation.

**Maintenance, inspection and parts replacement**

- Do not carry out a megger (insulation resistance) test on the control circuit of the inverter. It will cause a failure.

**Disposal**

- The inverter must be treated as industrial waste.

## General instruction

- Many of the diagrams and drawings in the Instruction Manual show the product without a cover or partially open for explanation. Never operate the product in this manner. The cover must be always reinstalled and the instruction in the Instruction Manual must be followed when operating the product. For more details on the PM motor, refer to the Instruction Manual of the PM motor.

# CONTENTS


## 1 INTRODUCTION 7

1.1 Product checking and accessories 8

1.2 Inverter component names 9

1.3 About the related manuals 10

## 2 INSTALLATION AND WIRING 11

2.1 Peripheral devices 12

2.1.1 Inverter and peripheral devices ..... 12
2.1.2 Peripheral devices ..... 14

2.2 Removal and reinstallation of the front cover 15

2.3 Installation of the inverter and enclosure design 17

2.3.1 Inverter installation environment ..... 17
2.3.2 Cooling system types for inverter enclosure ..... 19
2.3.3 Inverter installation ..... 20
2.3.4 Protruding the heatsink ..... 22

2.4 Terminal connection diagrams 24

2.5 Main circuit terminals 28

2.5.1 Details on the main circuit terminals of the inverter ..... 28
2.5.2 Details on the main circuit terminals of the converter unit (FR-CC2) ..... 28
2.5.3 Terminal layout of the main circuit terminals, wiring of power supply and the motor ..... 29
2.5.4 Applicable cables and wiring length ..... 30
2.5.5 Earthing (grounding) precautions ..... 32

2.6 Control circuit 33

2.6.1 Details on the control circuit terminals of the inverter ..... 33
2.6.2 Details on the control circuit terminals of the converter unit (FR-CC2) ..... 37
2.6.3 Control logic (sink/source) change ..... 38
2.6.4 Wiring of inverter control circuit ..... 40
2.6.5 Wiring precautions ..... 42
2.6.6 When using separate power supplies for the control circuit and the main circuit ..... 43
2.6.7 When supplying 24 V external power to the control circuit ..... 44
2.6.8 Safety stop function ..... 45

2.7 Communication connectors and terminals 47

2.7.1 PU connector ..... 47
2.7.2 USB connector ..... 48
2.7.3 RS-485 terminal block ..... 49

2.8 Connection of motor with encoder (vector control) 50

2.9 Connection of stand-alone option units 57

2.9.1 Connection of the brake unit (FR-BU2) ..... 57
2.9.2 Connection of the high power factor converter (FR-HC2) ..... 58

# 3 PRECAUTIONS FOR USE OF THE INVERTER 59

**3.1 Electro-magnetic interference (EMI) and leakage currents 60**

3.1.1 Leakage currents and countermeasures ... 60
3.1.2 Countermeasures against inverter-generated EMI ... 63
3.1.3 Converter unit (FR-CC2) built-in EMC filter ... 66

**3.2 Power supply harmonics 67**

3.2.1 Power supply harmonics ... 67
3.2.2 Harmonic Suppression Guidelines in Japan ... 68

**3.3 Installation of a reactor 70**

**3.4 Power-OFF and magnetic contactor (MC) 71**

**3.5 Countermeasures against deterioration of the 400 V class motor insulation 72**

**3.6 Checklist before starting operation 73**

**3.7 Failsafe system which uses the inverter 76**

# 4 PROTECTIVE FUNCTIONS 79

**4.1 Inverter fault and alarm indications 80**

**4.2 Reset method for the protective functions 80**

**4.3 Check and clear of the faults history 81**

**4.4 List of fault displays 83**

# 5 PRECAUTIONS FOR MAINTENANCE AND INSPECTION 85

**5.1 Inspection item 86**

5.1.1 Daily inspection ... 86
5.1.2 Periodic inspection ... 86
5.1.3 Daily and periodic inspection ... 87
5.1.4 Checking the inverter and converter modules ... 88
5.1.5 Cleaning ... 89
5.1.6 Replacement of parts ... 89
5.1.7 Inverter replacement ... 91

**5.2 Measurement of main circuit voltages, currents and powers 92**

5.2.1 Measurement of powers ... 94
5.2.2 Measurement of voltages and use of PT ... 94
5.2.3 Measurement of currents ... 95
5.2.4 Use of CT and transducer ... 95
5.2.5 Example of measuring converter unit (FR-CC2) input power factor ... 95
5.2.6 Measurement of converter output voltage (across terminals P and N) ... 95
5.2.7 Measurement of inverter output frequency ... 96

5.2.8 Insulation resistance test using megger ..... 96
5.2.9 Pressure test ..... 96

# 6 SPECIFICATIONS 97

**6.1 Inverter rating 98**

**6.2 Common specifications 100**

**6.3 Outline dimension drawings 102**

6.3.1 Inverter outline dimension drawings ..... 102
6.3.2 Converter unit (FR-CC2) outline dimension drawings ..... 104

# APPENDIX 105

**Appendix1 For customers replacing the conventional model with this inverter ..... 106**
**Appendix2 Comparison with FR-A840 ..... 108**
**Appendix3 Instructions for compliance with the EU Directives ..... 109**
**Appendix4 Instructions for UL and cUL ..... 111**

MEMO

# 1 INTRODUCTION

**This chapter contains the descriptions that must be read before using this product.**
**Always read the instructions before using the equipment.**


1.1 Product checking and accessories ..... 8
1.2 Inverter component names ..... 9


<Abbreviations>

DU ..... Operation panel (FR-DU08)
PU ..... Operation panel (FR-DU08) and parameter unit (FR-PU07)
Inverter ..... Mitsubishi inverter FR-A800 series (Separated converter type)
Pr. ..... Parameter number (Number assigned to function)
PU operation ..... Operation using the PU (FR-DU08/FR-PU07)
External operation ..... Operation using the control circuit signals
Combined operation ..... Combined operation using the PU (FR-DU08/FR-PU07) and External operation

<Notes on descriptions in this Instruction Manual>

- Connection diagrams in this Instruction Manual suppose that the control logic of the input terminal is the sink logic, unless otherwise specified. (For the control logic, refer to page 38.)

| Harmonic Suppression Guidelines |
| --- |
| All the models of the inverters used by specific consumers are covered by "the Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage". For the details, refer to page 68. |

# 1.1 Product checking and accessories

Unpack the product and check the capacity plate on the front cover and the rating plate on the side to ensure that the model agrees with the order and the product is intact.

## ● Applicable inverter model

| Symbol | Voltage class |
|---|---|
| 4 | 400V class |

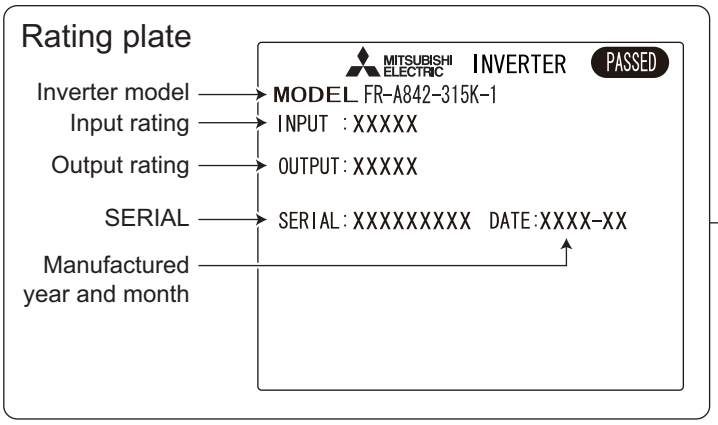
| Symbol | Structure, functionality |
|---|---|
| 2 | Separated converter type |

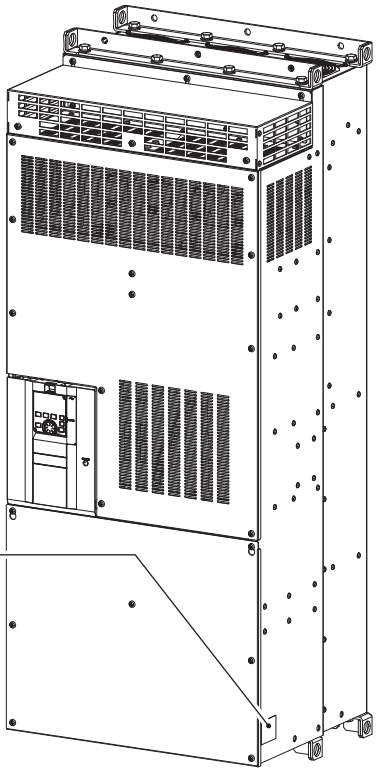
| Symbol | Description |
|---|---|
| 315K to 500K | ND rated inverter capacity (kW) |
| 07700 to 12120 | SLD rated inverter current (A) |

| Symbol | Type*1 |
|---|---|
| -1 | FM |
| -2 | CA |

FR-A842-315K-1□

| Symbol | Circuit board coating (3C2) | Plated conductor |
|---|---|---|
| Not used | Not used | Not used |
| -60 | With | Not used |
| -06 | With | With |



*1 Specification differs by the type as follows.

| Type | Monitor output | Initial setting | | | |
|---|---|---|---|---|---|
| | | Built-in EMC filter | Control logic | Rated frequency | Pr.19 Base frequency voltage |
| FM (terminal FM equipped model) | Terminal FM (pulse train output)<br>Terminal AM (analog voltage output (0 to ±10 VDC)) | OFF | Sink logic | 60 Hz | 9999 (same as the power supply voltage) |
| CA (terminal CA equipped model) | Terminal CA (analog current output (0 to 20 mA DC))<br>Terminal AM (analog voltage output (0 to ±10 VDC)) | ON | Source logic | 50 Hz | 8888 (95% of the power supply voltage) |

**NOTE**

- Hereinafter, the inverter model name consists of the rated current and the applicable motor capacity.
  (Example) FR-A842-07700(315K)

## ● How to read the SERIAL number

Rating plate example

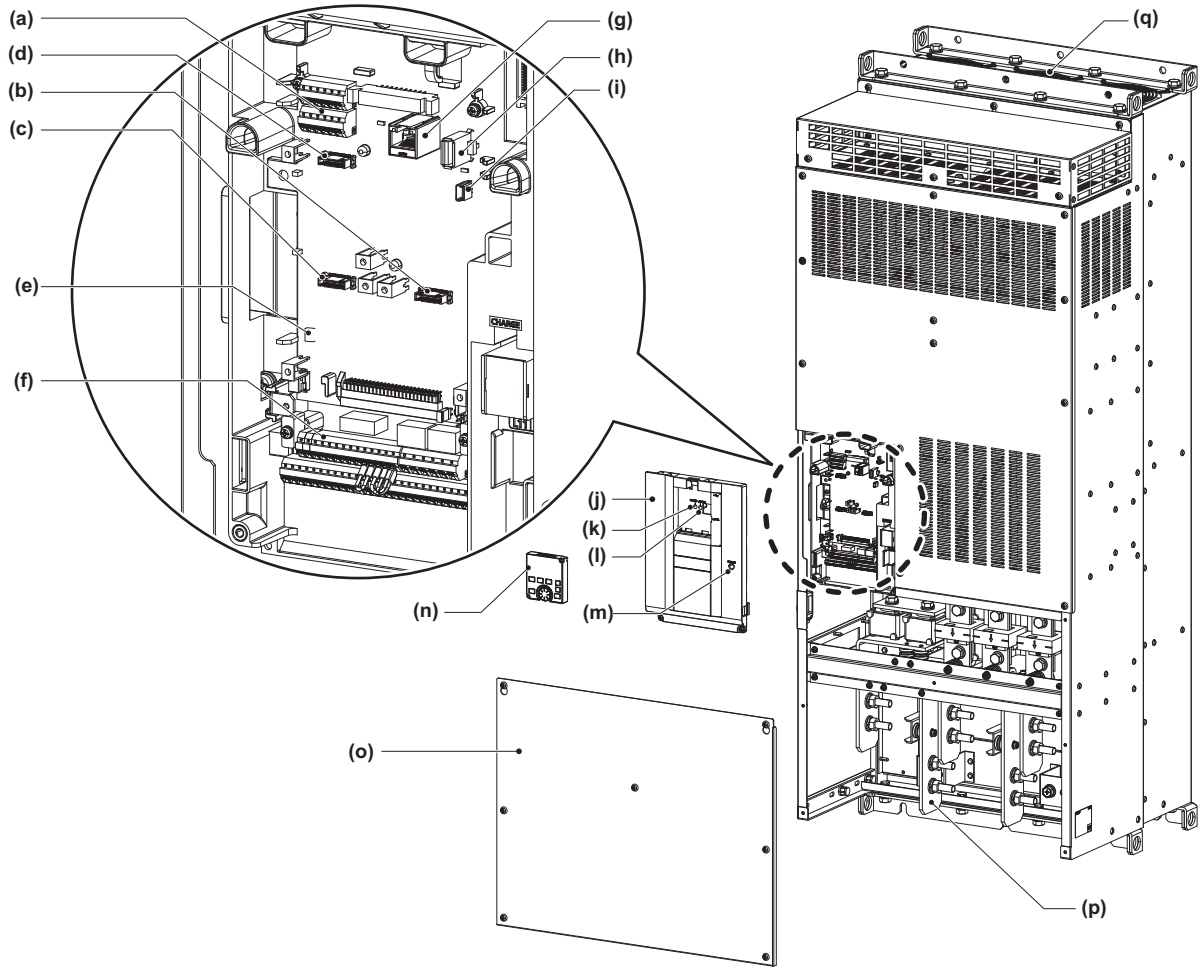
| □ | ○ | ○ | ○○○○○○ |
|---|---|---|---|
| Symbol | Year | Month | Control number |

SERIAL

The SERIAL consists of one symbol, two characters indicating the production year and month, and six characters indicating the control number.
The last digit of the production year is indicated as the Year, and the Month is indicated by 1 to 9, X (October), Y (November), or Z (December).

# 1.2 Inverter component names

Component names are shown below.




| Symbol | Name | Description | Refer to page |
|---|---|---|---|
| (a) | RS-485 terminals | Enables RS-485 and Modbus-RTU communication. | 49 |
| (b) | Plug-in option connector 1 | Connects a plug-in option or a communication option. | Instruction Manual of the option |
| (c) | Plug-in option connector 2 | | |
| (d) | Plug-in option connector 3 | | |
| (e) | Voltage/current input switch | Selects between voltage and current for the terminal 2 and 4 inputs. | *1 |
| (f) | Control circuit terminal block | Connects cables for the control circuit. | 33 |
| (g) | PU connector | Connects the operation panel (FR-DU08) or the parameter unit (FR-PU07). This connector also enables the RS-485 communication. | 47 |
| (h) | USB A connector | Connects a USB memory device. | 48 |
| (i) | USB mini B connector | Connects a personal computer and enables communication with FR Configurator2. | 48 |
| (j) | Front cover | Remove this cover for the installation of the product, installation of a plug-in (communication) option, RS-485 terminal wiring, switching of the voltage/ current input switch, etc. | 15 |
| (k) | Power lamp | Stays ON while the power is supplied to the control circuit (R1/L11, S1/L21). | 29 |
| (l) | Alarm lamp | Turns ON when the protective function of the inverter is activated. | 79 |
| (m) | Charge lamp | Stays ON while the power is supplied to the main circuit. | 29 |
| (n) | Operation panel (FR-DU08) | Operates and monitors the inverter. | *1 |
| (o) | Terminal block cover | Remove this cover for wiring. | 15 |
| (p) | Main circuit terminal block | Connects cables for the main circuit. | 28 |
| (q) | Cooling fan | Cools the inverter. | 90 |

*1 Refer to the FR-A800 Instruction Manual (Detailed)

# 1.3 About the related manuals

The manuals related to FR-A800 are shown below.

| Manual name | Manual number |
|---|---|
| FR-A800 Instruction Manual (Detailed) | IB-0600503ENG |
| FR-CC2 Instruction Manual | IB-0600543ENG |
| FR Configurator2 Instruction Manual | IB-0600516ENG |
| FR-A800 PLC Function Programming Manual | IB-0600492ENG |
| FR-A800Safety stop function instruction manual | BNC-A23228-001 |

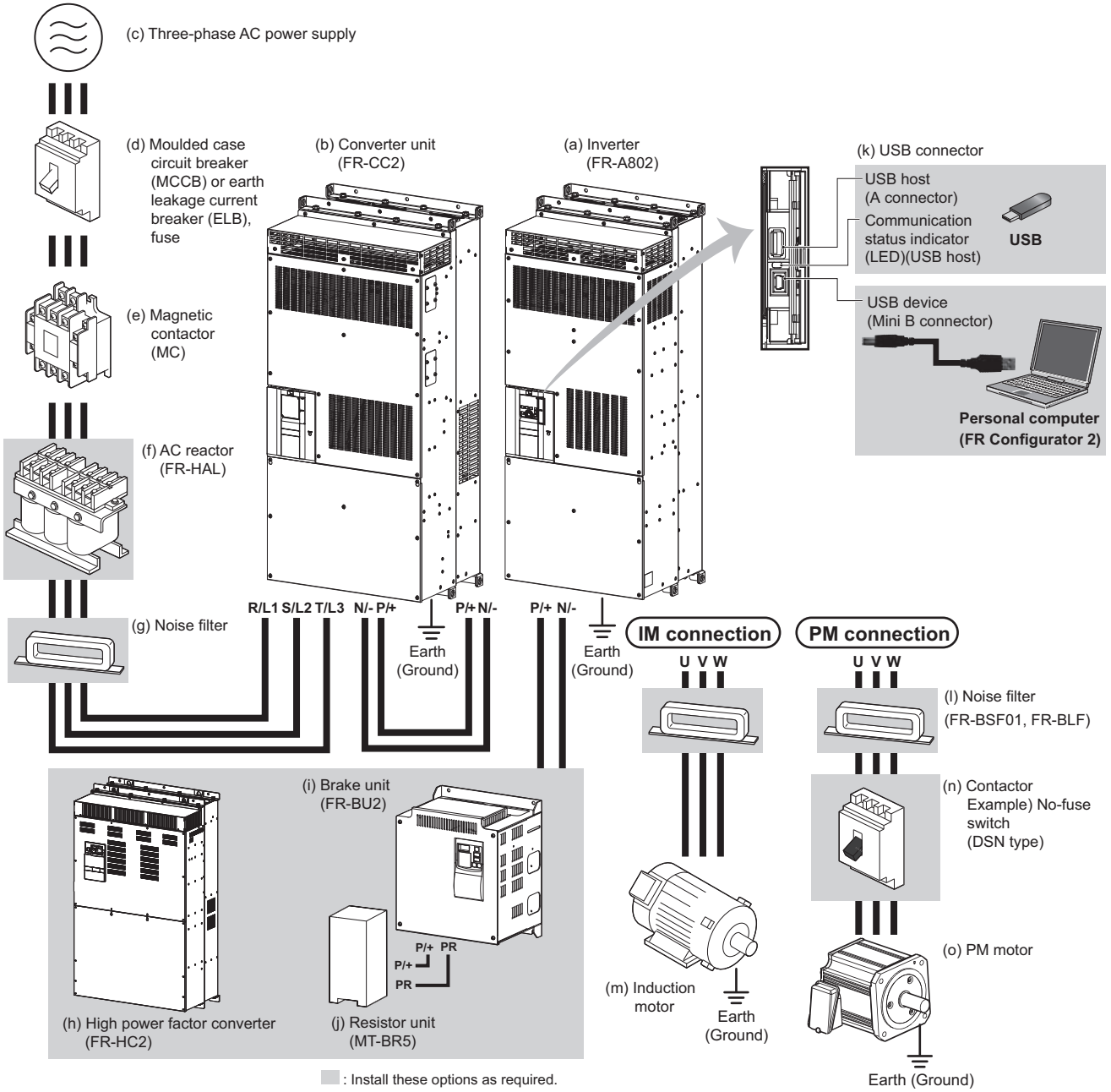
# 2 INSTALLATION AND WIRING

**This chapter explains the "installation" and the "wiring" of this product.**
**Always read the instructions before using the equipment.**


2.1 Peripheral devices ..... 12
2.2 Removal and reinstallation of the front cover ..... 15
2.3 Installation of the inverter and enclosure design ..... 17
2.4 Terminal connection diagrams ..... 24
2.5 Main circuit terminals ..... 28
2.6 Control circuit ..... 33
2.7 Communication connectors and terminals ..... 47
2.8 Connection of motor with encoder (vector control) ..... 50
2.9 Connection of stand-alone option units ..... 57

# 2.1 Peripheral devices

## 2.1.1 Inverter and peripheral devices




**NOTE**

- To prevent an electric shock, always earth (ground) the motor, the inverter, and the converter unit.
- Do not install a power factor correction capacitor or surge suppressor or capacitor type filter on the inverter's output side. Doing so will cause the inverter to trip or the capacitor and surge suppressor to be damaged. If any of the above devices is connected, immediately remove it. When installing a molded case circuit breaker on the output side of the inverter, contact the manufacturer of the molded case circuit breaker.
- Electromagnetic wave interference
  The input/output (main circuit) of the inverter or the converter unit includes high frequency components, which may interfere with the communication devices (such as AM radios) used near the inverter or the converter unit. In this case, activating the EMC filter of the converter unit may minimize interference. (Refer to page 66.)
- For details of options and peripheral devices, refer to the respective Instruction Manual.
- A PM motor cannot be driven by the commercial power supply.
- A PM motor is a motor with permanent magnets embedded inside. High voltage is generated at the motor terminals while the motor is running. Before closing the contactor at the output side, make sure that the inverter power is ON and the motor is stopped.

| Symbol | Name | Overview | Refer to page |
|---|---|---|---|
| (a) | Inverter (FR-A802) | The life of the inverter and the converter unit is influenced by the surrounding air temperature.<br>The surrounding air temperature should be as low as possible within the permissible range. This must be noted especially when the inverter is installed in an enclosure.<br>Incorrect wiring may lead to damage of the inverter and the converter unit.<br>The control signal lines must be kept fully away from the main circuit lines to protect them from noise.<br>The converter unit built-in EMC filter can reduce the noise. | 17<br>24<br>66 |
| (b) | Converter unit (FR-CC2) | | |
| (c) | Three-phase AC power supply | Must be within the permissible power supply specifications of the converter unit. | 98 |
| (d) | Molded case circuit breaker (MCCB), earth leakage circuit breaker (ELB), or fuse | Must be selected carefully since an inrush current flows in the converter unit at power ON. | 14 |
| (e) | Magnetic contactor (MC) | Install this to ensure safety.<br>Do not use this to start and stop the inverter. Doing so will shorten the life of the inverter and the converter unit. | 71 |
| (f) | AC reactor (FR-HAL) | Install this to suppress harmonics and to improve the power factor.<br>An AC reactor (FR-HAL) (option) is required when installing the inverter near a large power supply system (1000 kVA or more). Under such condition, the inverter and the converter unit may be damaged if you do not use a reactor.<br>Select a reactor according to the applied motor capacity. | 70 |
| (g) | Noise filter | Suppresses the noise radiated from the power supply side of the converter unit. | 63 |
| (h) | High power factor converter (FR-HC2) | Suppresses the power supply harmonics significantly. Install these options as required.<br>When FR-HC2 is used, FR-CC2 is not required. | 58 |
| (i) | Brake unit (FR-BU2) | Allows the inverter to provide the optimal regenerative braking capability.<br>Install these options as required. | 57 |
| (j) | Resistor unit (MT-BR5) | | |
| (k) | USB connection | A USB (Ver. 1.1) cable connects the inverter with a personal computer.<br>A USB memory device enables parameter copies and the trace function. | 48 |
| (l) | Noise filter | Install this to reduce the electromagnetic noise generated from the inverter and the converter unit. The noise filter is effective in the range from about 0.5 MHz to 5 MHz. | 63 |
| (m) | Induction motor | Connect a squirrel-cage induction motor. | — |
| (n) | Contactor<br>Example) No-fuse switch (DSN type) | Connect this for an application where a PM motor is driven by the load even while the inverter power is OFF. Do not open or close the contactor while the inverter is running (outputting). | — |
| (o) | PM motor | A PM motor can be used. A PM motor cannot be driven by the commercial power supply. | — |

# 2.1.2 Peripheral devices

## ◆Selecting the converter unit (FR-CC2)

Select the capacity of the FR-CC2 converter unit according to the connected motor capacity.

| Motor capacity (kW) *1 | Converter unit FR-CC2-[ ] | Inverter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SLD (superlight duty) | | | LD (light duty) | | | ND (normal duty, initial value) | | | HD (heavy duty) | | |
| | | Model FR-A842-[ ] | | Rated current (A) | Model FR-A842-[ ] | | Rated current (A) | Model FR-A842-[ ] | | Rated current (A) | Model FR-A842-[ ] | | Rated current (A) |
| 280 | H315 | - | - | - | - | - | - | - | - | - | 315K | 07700 | 547 |
| 315 | H315K | - | - | - | - | - | - | 315K | 07700 | 610 | 355K | 08660 | 610 |
| 355 | H355K | - | - | - | 315K | 07700 | 683 | 355K | 08660 | 683 | 400K | 09620 | 683 |
| 400 | H400K | 315K | 07700 | 770 | 355K | 08660 | 770 | 400K | 09620 | 770 | 450K | 10940 | 770 |
| 450 | H450K | 355K | 08660 | 866 | 400K | 09620 | 866 | 450K | 10940 | 866 | 500K | 12120 | 866 |
| 500 | H500K | 400K | 09620 | 962 | 450K | 10940 | 962 | 500K | 12120 | 962 | - | - | - |

*1 The applicable motor capacity indicated is the maximum capacity applicable for use of the Mitsubishi 4-pole standard motor.

## ◆Selecting the breaker/magnetic contactor

Check the model of the inverter and the converter unit you purchased. Appropriate peripheral devices must be selected according to the capacity.

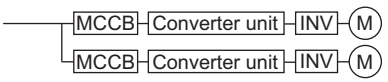
Refer to the table below to prepare appropriate peripheral devices.

• 400 V class

| Motor output (kW)*1 | Applicable converter model | Molded case circuit breaker (MCCB)*2 or earth leakage circuit breaker (ELB) (NF, NV type) | Input-side magnetic contactor*3 |
|---|---|---|---|
| 315 | FR-CC2-H315K | 700A | S-N600 |
| 355 | FR-CC2-H355K | 800A | S-N600 |
| 400 | FR-CC2-H400K | 900A | S-N800 |
| 450 | FR-CC2-H450K | 1000A | 1000A rated product |
| 500 | FR-CC2-H500K | 1200A | 1000A rated product |

*1 Assumes the use of a Mitsubishi 4-pole standard motor with the power supply voltage of 400 VAC 50 Hz.

*2 Select an MCCB according to the power supply capacity.
Install one MCCB per converter.
For the use in the United States or Canada, provide the appropriate UL and cUL listed fuse or UL489 molded case circuit breaker (MCCB) that is suitable for branch circuit protection. (Refer to page 111.)




*3 The magnetic contactor is selected based on the AC-1 class. The electrical durability of magnetic contactor is 500,000 times. When the magnetic contactor is used for emergency stops during motor driving, the electrical durability is 25 times.
If using an MC for emergency stop during driving the motor, select an MC regarding the converter unit input side current as JEM1038-AC-3 class rated current. When using an MC on the inverter output side for commercial-power supply operation switching using a general-purpose motor, select an MC regarding the rated motor current as JEM1038-AC-3 class rated current.

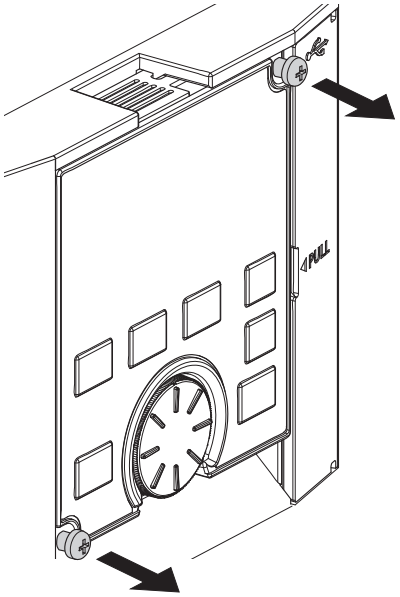
NOTE

- When the converter unit capacity is larger than the motor capacity, select an MCCB and a magnetic contactor according to the converter unit model, and select cables and reactors according to the motor output.
- When the breaker on the converter unit's input side trips, check for the wiring fault (short circuit), damage to internal parts of the inverter and the converter unit, etc. The cause of the trip must be identified and removed before turning ON the power of the breaker.

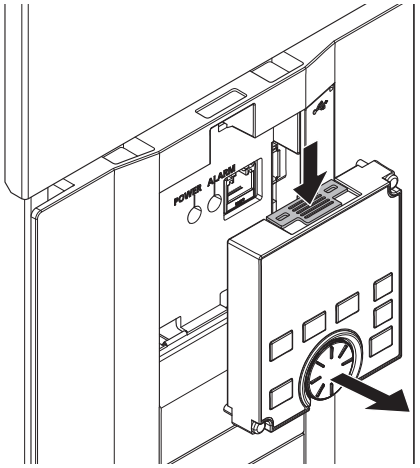
# 2.2 Removal and reinstallation of the front cover

## ◆Removal and reinstallation of the operation panel

- Loosen the two screws on the operation panel. (These screws cannot be removed.)



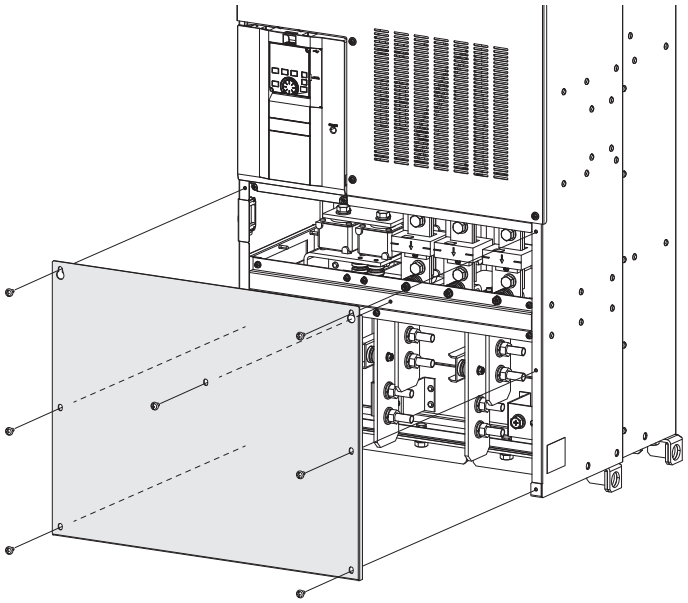

- Push the upper part of the operation panel and pull the operation panel to remove.



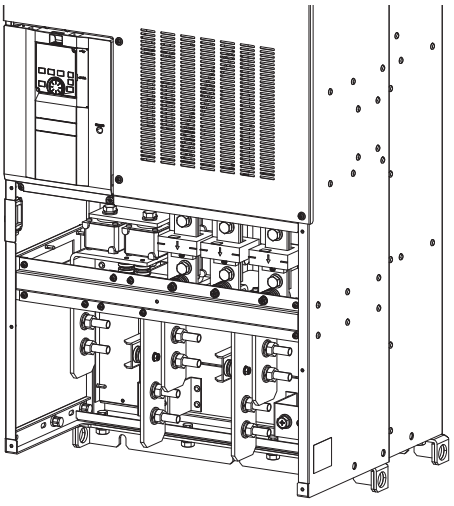

To reinstall the operation panel, align its connector on the back with the PU connector of the inverter, and insert the operation panel. After confirming that the operation panel is fit securely, tighten the screws. (Tightening torque: 0.40 to 0.45 N·m)

## ◆Removal of the terminal block cover

(a)

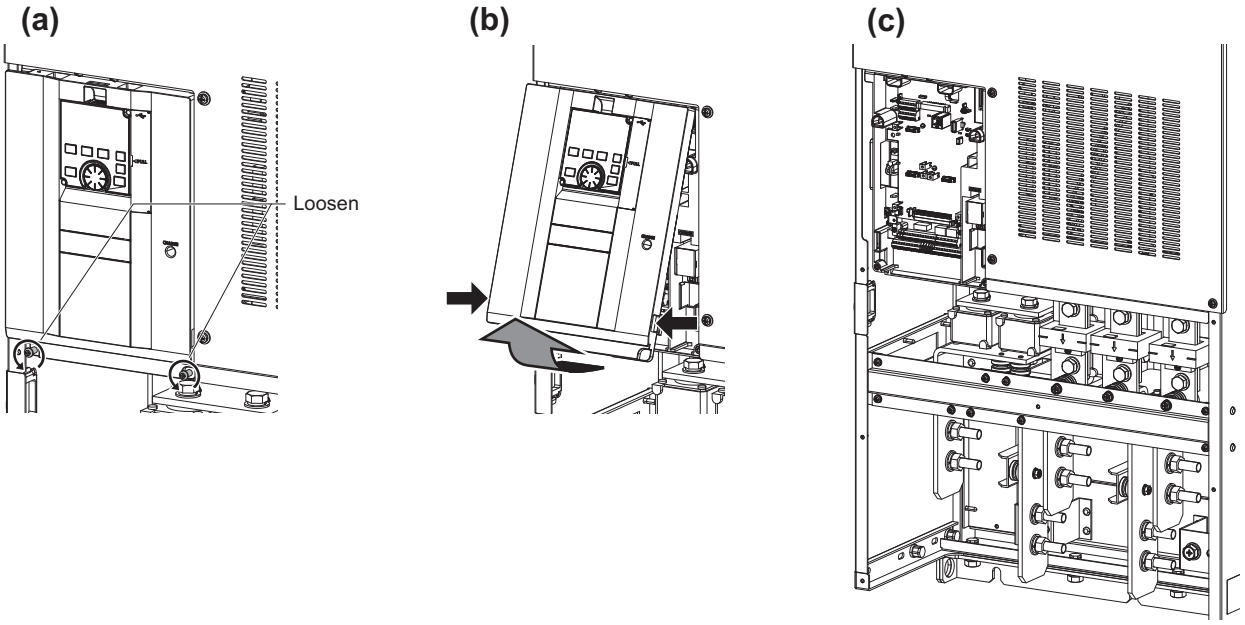


(b)



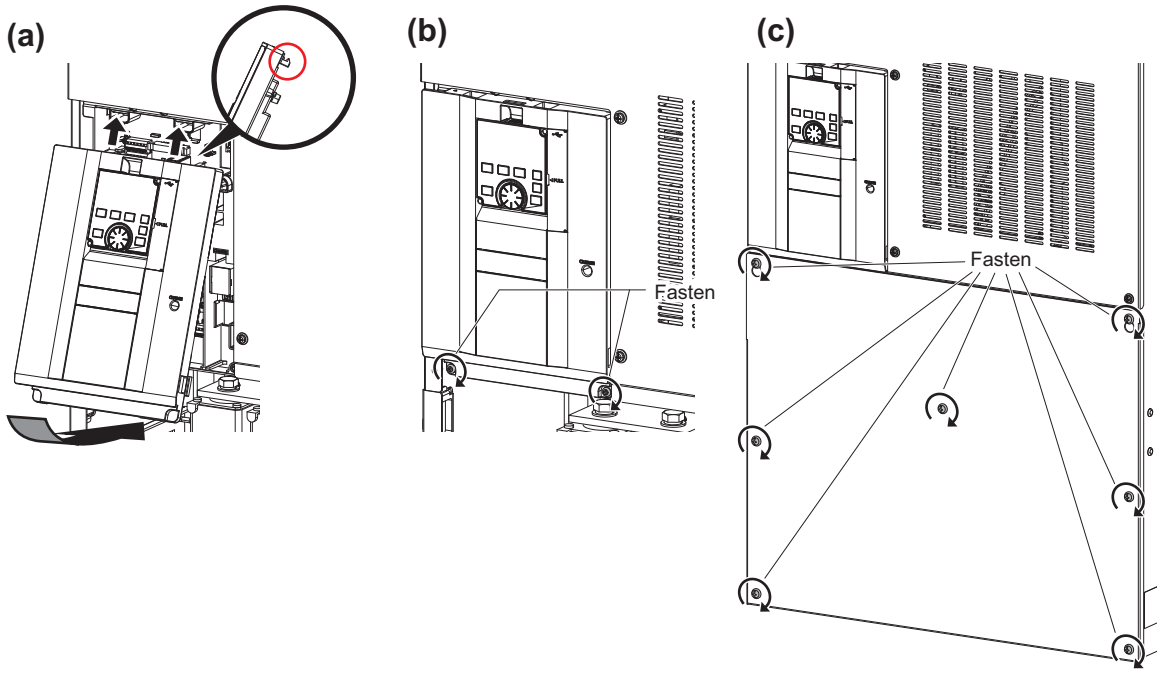
(a) Remove the mounting screws to remove the terminal block cover. (The number of the mounting screws differs by the capacity.)
(b) With the terminal block cover removed, wiring of the main circuit terminals can be performed.

## ◆Removal of the front cover




(a) With the terminal block cover removed, loosen the mounting screws on the front cover. These screws cannot be removed.
(b) While holding the areas around the installation hooks on the sides of the front cover, pull out the front cover using its upper side as a support.
(c) With the front cover removed, wiring of the control circuit and the RS-485 terminals, and installation of the plug-in option can be performed.

## ◆Reinstallation of the front cover and the terminal block cover




(a) Insert the upper hooks of the front cover into the sockets of the inverter.
Securely install the front cover to the inverter by fixing the hooks on the sides of the cover into place.
(b) Tighten the mounting screw at the lower part of the front cover.
(c) Fasten the terminal block cover with the mounting screws. (The number of the mounting screws differs by the capacity.)

**NOTE**

- Fully make sure that the front cover and the terminal block cover are installed securely. Always tighten the mounting screws of the front cover and the terminal block cover.

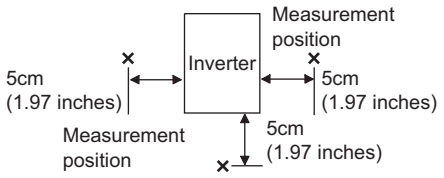
# 2.3 Installation of the inverter and enclosure design

When designing or manufacturing an inverter enclosure, determine the structure, size, and device layout of the enclosure by fully considering the conditions such as heat generation of the contained devices and the operating environment. An inverter uses many semiconductor devices. To ensure higher reliability and long period of operation, operate the inverter in the ambient environment that completely satisfies the equipment specifications.

## 2.3.1 Inverter installation environment

The following table lists the standard specifications of the inverter installation environment. Using the inverter in an environment that does not satisfy the conditions deteriorates the performance, shortens the life, and causes a failure. Refer to the following points, and take adequate measures.

### ◆Standard environmental specifications of the inverter

| Item | | Description |
|---|---|---|
| Surrounding air temperature | LD, ND (initial setting), HD | -10 to +50°C (non-freezing) |
| | SLD | -10 to +40°C (non-freezing) |
| | |  |
| Surrounding air humidity | | With circuit board coating 95% RH or less (non-condensing)<br>Without circuit board coating 90% RH or less (non-condensing) |
| Storage temperature | | -20 to + 65°C*1 |
| Atmosphere | | Indoors (free from corrosive gas, flammable gas, oil mist, dust and dirt) |
| Altitude | | Maximum 1,000 m above sea level*2 |
| Vibration | | 2.9 m/s$^2$ or less at 10 to 55 Hz (directions of X, Y, Z axes) |

*1 Temperature applicable for a short time, e.g. in transit.

*2 For the installation at an altitude above 1,000 m (up to 2,500 m), derate the rated current 3% per 500 m.

### ◆Temperature

The permissible surrounding air temperature of the inverter is between -10°C and +50°C (-10°C and +40°C at the SLD rating). Always operate the inverter within this temperature range. Operation outside this range will considerably shorten the service lives of the semiconductors, parts, capacitors and others. Take the following measures to keep the surrounding air temperature of the inverter within the specified range.

(a) Measures against high temperature

- Use a forced ventilation system or similar cooling system. (Refer to page 19.)
- Install the enclosure in an air-conditioned electric chamber.
- Block direct sunlight.
- Provide a shield or similar plate to avoid direct exposure to the radiated heat and wind of a heat source.
- Ventilate the area around the enclosure well.

(b) Measures against low temperature

- Provide a space heater in the enclosure.
- Do not power OFF the inverter. (Keep the start signal of the inverter OFF.)

(c) Sudden temperature changes

- Select an installation place where temperature does not change suddenly.
- Avoid installing the inverter near the air outlet of an air conditioner.
- If temperature changes are caused by opening/closing of a door, install the inverter away from the door.

### ◆Humidity

Operate the inverter within the ambient air humidity of usually 45 to 90% (up to 95% with circuit board coating). Too high humidity will pose problems of reduced insulation and metal corrosion. On the other hand, too low humidity may cause a spatial electrical breakdown. The insulation distance defined in JEM1103 "Control Equipment Insulator" is humidity of 45 to 85%.

(a) Measures against high humidity
- Make the enclosure enclosed, and provide it with a hygroscopic agent.
- Provide dry air into the enclosure from outside.
- Provide a space heater in the enclosure.

(b) Measures against low humidity
Air with proper humidity can be blown into the enclosure from outside. Also when installing or inspecting the unit, discharge your body (static electricity) beforehand, and keep your body away from the parts and patterns.

(c) Measures against condensation
Condensation may occur if frequent operation stops change the in-enclosure temperature suddenly or if the outside air temperature changes suddenly.
Condensation causes such faults as reduced insulation and corrosion.
- Take the measures against high humidity in (a).
- Do not power OFF the inverter. (Keep the start signal of the inverter OFF.)

## ◆Dust, dirt, oil mist

Dust and dirt will cause such faults as poor contacts, reduced insulation and cooling effect due to the moisture-absorbed accumulated dust and dirt, and in-enclosure temperature rise due to a clogged filter. In an atmosphere where conductive powder floats, dust and dirt will cause such faults as malfunction, deteriorated insulation and short circuit in a short time. Since oil mist will cause similar conditions, it is necessary to take adequate measures.

Countermeasure
- Place the inverter in a totally enclosed enclosure.
  Take measures if the in-enclosure temperature rises. (Refer to page 19.)
- Purge air.
  Pump clean air from outside to make the in-enclosure air pressure higher than the outside air pressure.

## ◆Corrosive gas, salt damage

If the inverter is exposed to corrosive gas or to salt near a beach, the printed board patterns and parts will corrode or the relays and switches will result in poor contact.
In such places, take the measures given above.

## ◆Explosive, flammable gases

As the inverter is non-explosion proof, it must be contained in an explosion-proof enclosure. In places where explosion may be caused by explosive gas, dust or dirt, an enclosure cannot be used unless it structurally complies with the guidelines and has passed the specified tests. This makes the enclosure itself expensive (including the test charges). The best way is to avoid installation in such places and install the inverter in a non-hazardous place.

## ◆High altitude

Use the inverter at an altitude of within 1000 m. For use at an altitude above 1,000 m (up to 2,500 m), derate the rated current 3% per 500 m.
If it is used at a higher place, it is likely that thin air will reduce the cooling effect and low air pressure will deteriorate dielectric strength.

## ◆Vibration, impact

The vibration resistance of the inverter is up to 2.9 $m/s^2$ at 10 to 55 Hz frequency and 1 mm amplitude for the directions of X, Y, Z axes. Applying vibration and impacts for a long time may loosen the structures and cause poor contacts of connectors, even if those vibration and impacts are within the specified values.
Especially when impacts are applied repeatedly, caution must be taken because such impacts may break the installation feet.

Countermeasure
- Provide the enclosure with rubber vibration isolators.
- Strengthen the structure to prevent the enclosure from resonance.
- Install the enclosure away from the sources of the vibration.

## 2.3.2 Cooling system types for inverter enclosure

From the enclosure that contains the inverter, the heat of the inverter and other equipment (transformers, lamps, resistors, etc.) and the incoming heat such as direct sunlight must be dissipated to keep the in-enclosure temperature lower than the permissible temperatures of the in-enclosure equipment including the inverter.

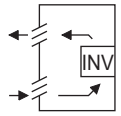
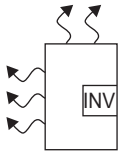
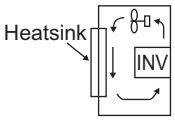
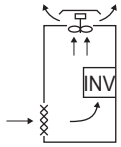
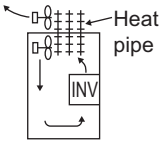
The cooling systems are classified as follows in terms of the cooling calculation method.

(a) Cooling by natural heat dissipation from the enclosure surface (totally enclosed type)

(b) Cooling by heatsink (aluminum fin, etc.)

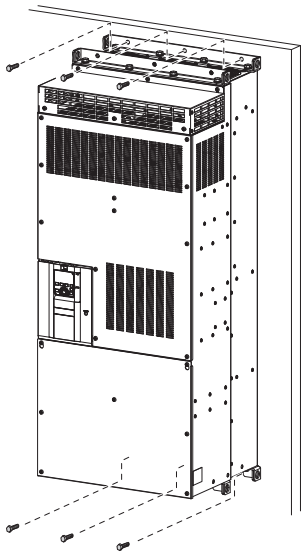
(c) Cooling by ventilation (forced ventilation type, pipe ventilation type)

(d) Cooling by heat exchanger or cooler (heat pipe, cooler, etc.)

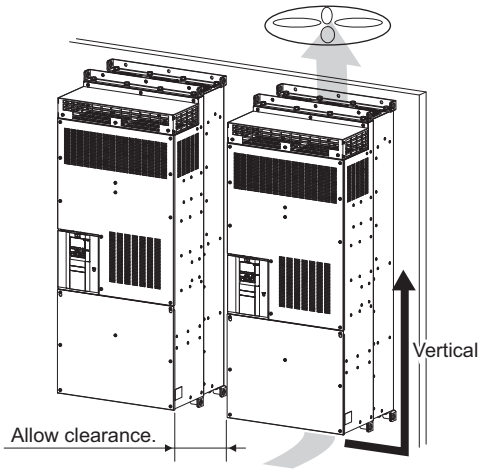
| Cooling system | | Enclosure structure | Comment |
|---|---|---|---|
| Natural cooling | Natural ventilation (enclosed, open type) |  | This system is low in cost and generally used, but the enclosure size increases as the inverter capacity increases. This system is for relatively small capacities. |
| | Natural ventilation (totally enclosed type) |  | Being a totally enclosed type, this system is the most appropriate for hostile environment having dust, dirt, oil mist, etc. The enclosure size increases depending on the inverter capacity. |
| Forced cooling | Heatsink cooling |  | This system has restrictions on the heatsink mounting position and area. This system is for relatively small capacities. |
| | Forced ventilation |  | This system is for general indoor installation. This is appropriate for enclosure downsizing and cost reduction, and often used. |
| | Heat pipe |  | This is a totally enclosed for enclosure downsizing. |

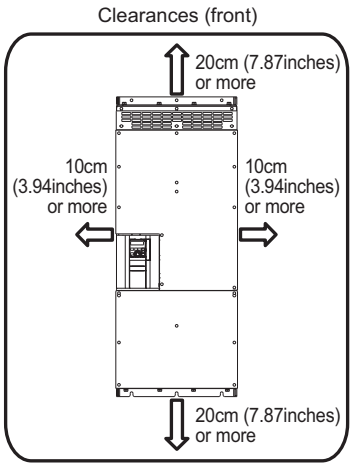
# 2.3.3 Inverter installation

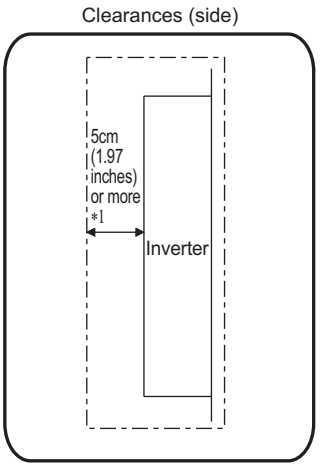
## ◆Inverter placement



- Install the inverter on a strong surface securely with screws.
- Leave enough clearances and take cooling measures.
- Avoid places where the inverter is subjected to direct sunlight, high temperature and high humidity.
- Install the inverter on a nonflammable wall surface.
- When encasing multiple inverters in an enclosure, install them in parallel as a cooling measure.
- For heat dissipation and maintenance, keep clearance between the inverter and the other devices or enclosure surface. The clearance below the inverter is required as a wiring space, and the clearance above the inverter is required as a heat dissipation space.




*1 For replacing the cooling fan, 30 cm (11.81 inches) or more of space is necessary in front of the inverter. Refer to page 90 for fan replacement.

## ◆Installation orientation of the inverter

Install the inverter on a wall as specified. Do not mount it horizontally or in any other way.

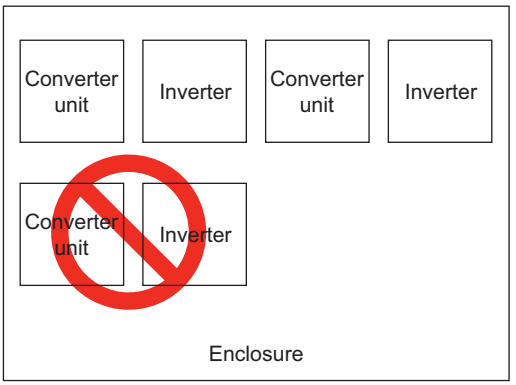
## ◆Above the inverter

Heat is blown up from inside the inverter by the small fan built in the unit. Any equipment placed above the inverter should be heat resistant.

## ◆Encasing multiple inverters and converter units

When multiple inverters and converter units are placed in the same enclosure, generally arrange them horizontally as shown in the figure on the right.
Do not place multiple products vertically. The exhaust air temperature of the inverter and the converter unit may be increased.

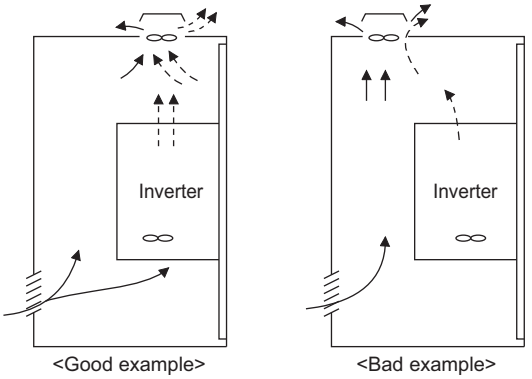
When mounting multiple inverters and converter units, fully take caution not to make the surrounding air temperature of the inverter and the converter unit higher than the permissible value by providing ventilation and increasing the enclosure size.




**Arrangement of multiple inverters and converter units**

## ◆Arrangement of the ventilation fan and inverter

Heat generated in the inverter is blown up from the bottom of the unit as warm air by the cooling fan. When installing a ventilation fan for that heat, determine the place of ventilation fan installation after fully considering an air flow. (Air passes through areas of low resistance. Make an airway and airflow plates to expose the inverter to cool air.)




**Arrangement of the ventilation fan and inverter**

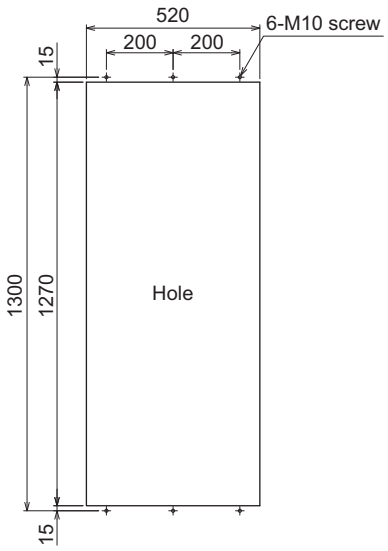
# 2.3.4 Protruding the heatsink

When encasing an inverter to an enclosure, the heat generated in the enclosure can be greatly reduced by protruding the heatsink of the inverter.
When installing the inverter in a compact enclosure, etc., this installation method is recommended.

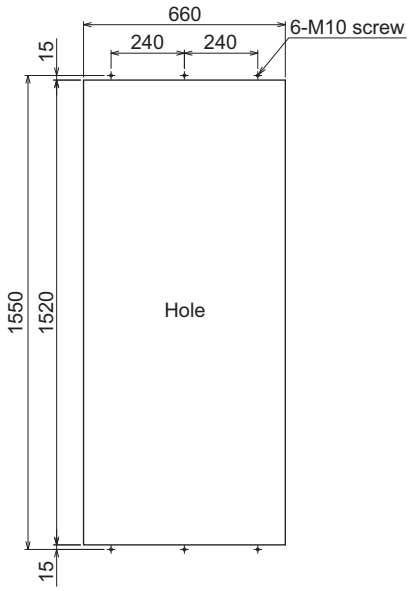
### ◆Panel cutting

Cut the panel of the enclosure according to the inverter capacity.

FR-A842-07700(315K)
FR-A842-08660(355K)

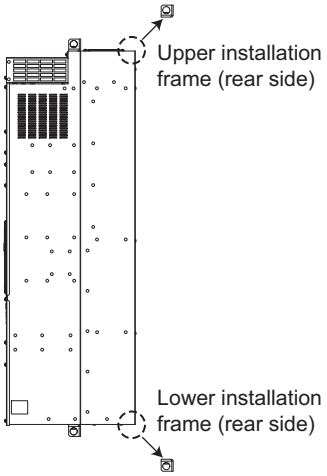



FR-A842-09620(400K)
FR-A842-10940(450K)
FR-A842-12120(500K)



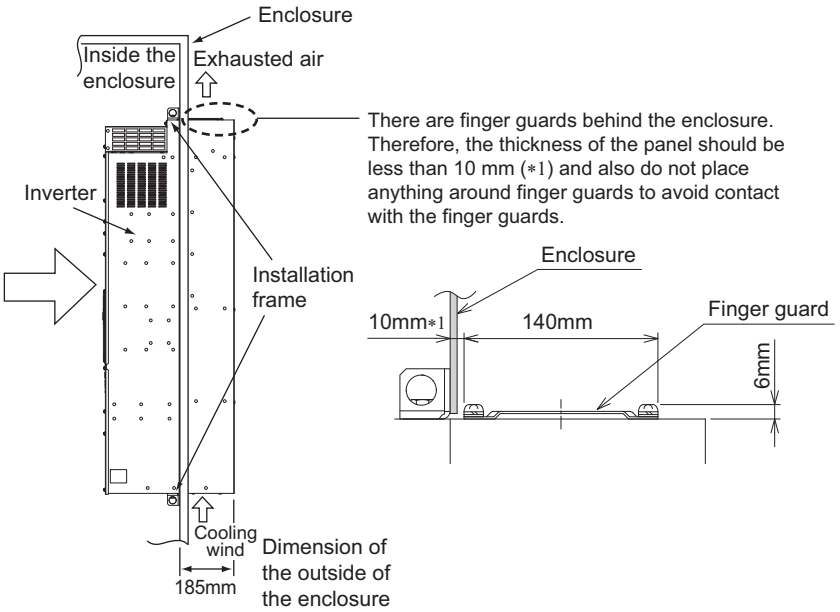
## ◆Removal of the rear installation frame

Two installation frames are attached to each of the upper and lower parts of the inverter. Remove the rear side installation frame on the top and bottom of the inverter as shown on the right.




## ◆Installation of the inverter

Push the inverter heatsink portion outside the enclosure and fix the enclosure and inverter with upper and lower installation frame.

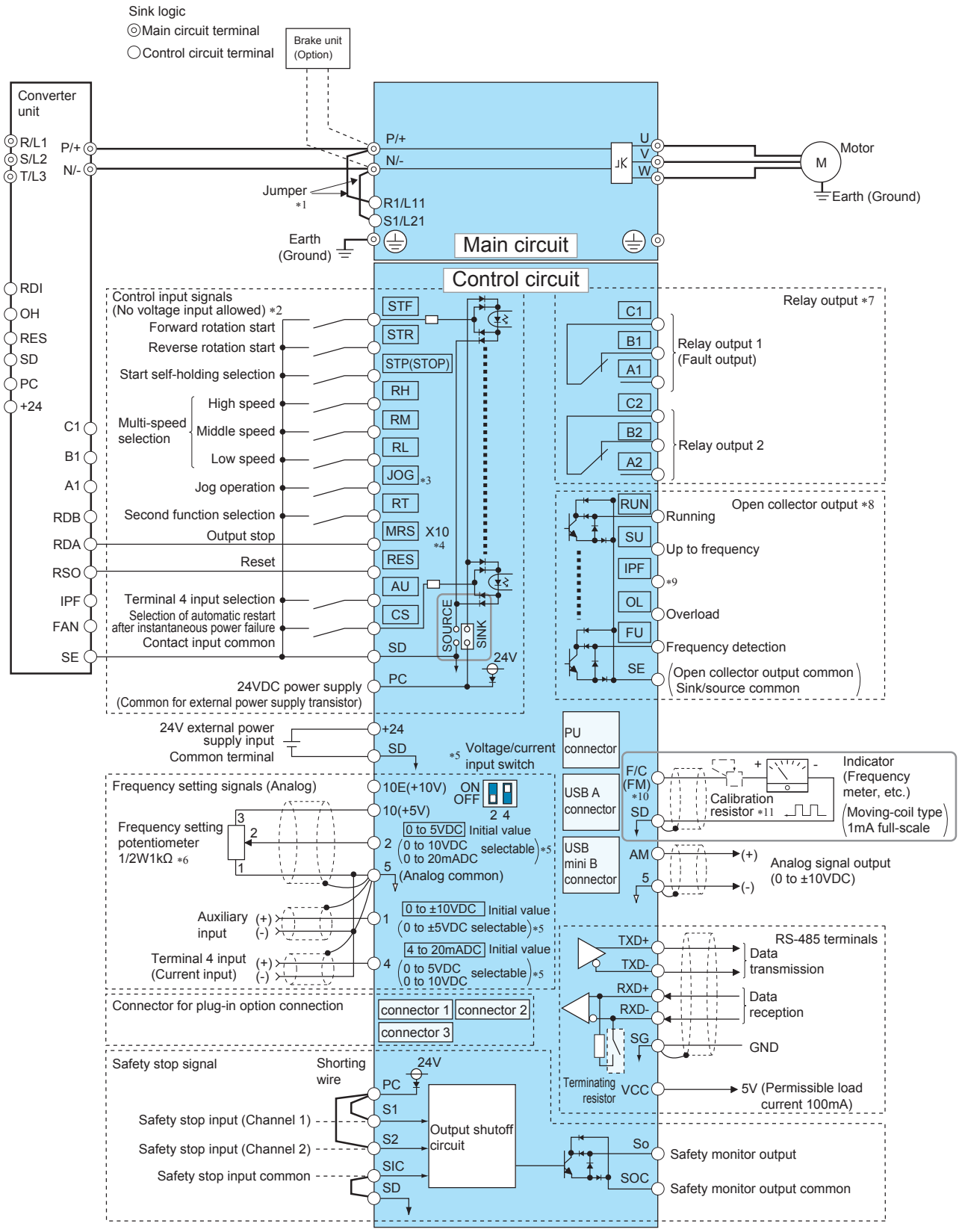



**NOTE**

- Having a cooling fan, the cooling section which comes out of the enclosure cannot be used in the environment of water drops, oil, mist, dust, etc.
- Be careful not to drop screws, dust etc. into the inverter and cooling fan section.

# 2.4 Terminal connection diagrams

## ◆FM type

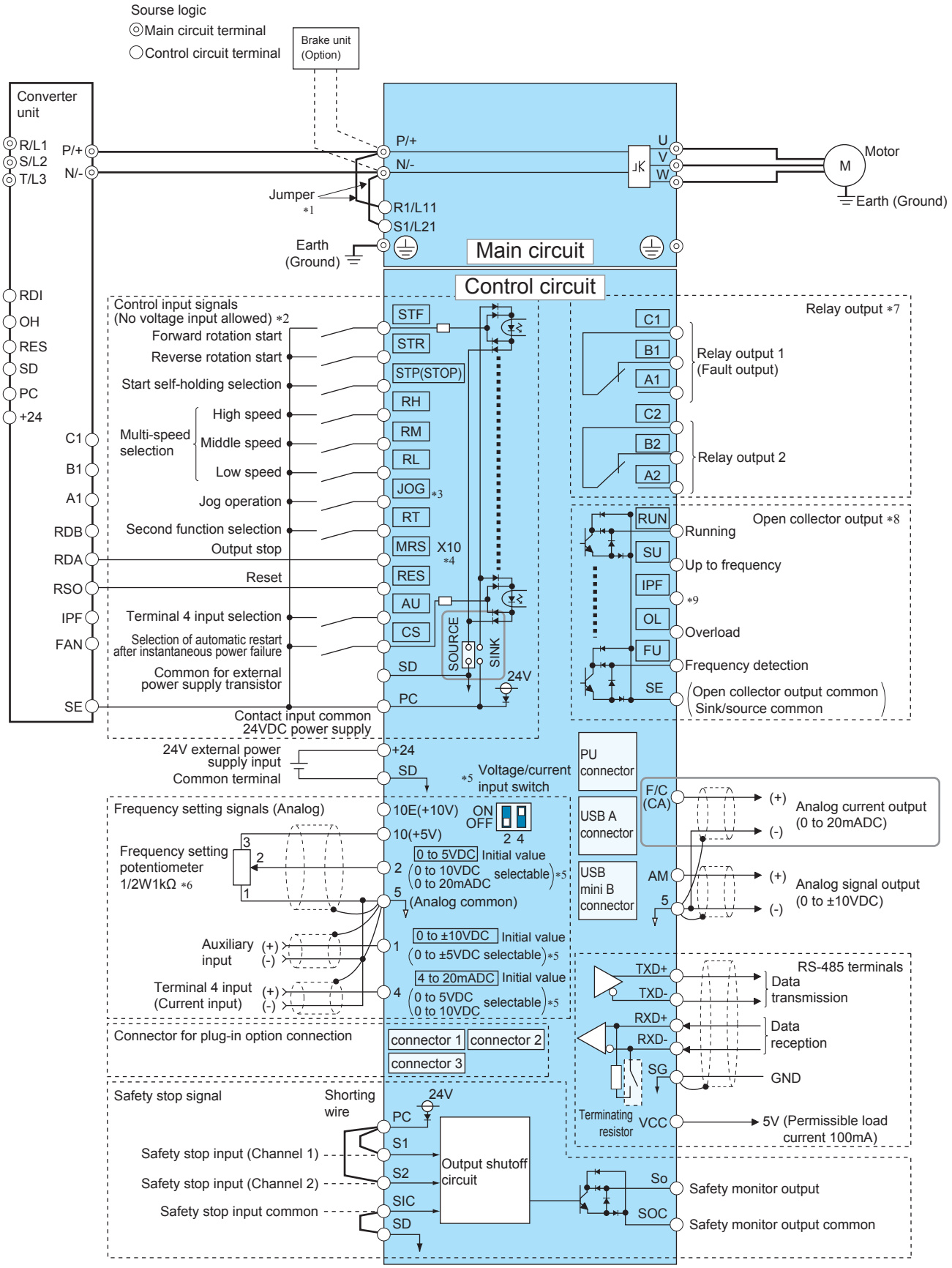


∗1 The terminals R1/L11 and S1/L21 are connected to the terminals P/+ and N/- with a jumper respectively. When using separate power supply for the control circuit, remove the jumpers from R1/L11 and S1/L21.
∗2 The function of these terminals can be changed with the input terminal assignment **(Pr.178 to Pr.189)**.
∗3 Terminal JOG is also used as the pulse train input terminal. Use **Pr.291** to choose JOG or pulse.
∗4 The X10 signal (NC contact input specification) is assigned to the terminal MRS in the initial setting. Set **Pr.599** = "0" to change the input specification of the X10 signal to NO contact.
∗5 Terminal input specifications can be changed by analog input specification switchover **(Pr.73, Pr.267).** To input a voltage (0 to 5 V/0 to 10 V), set the voltage/current input switch OFF. To input a current (4 to 20 mA), set the voltage/current input switch ON. Terminals 10 and 2 are also used as a PTC input terminal. **(Pr.561)**
∗6 It is recommended to use 2 W 1 kΩ when the frequency setting signal is changed frequently.
∗7 The function of these terminals can be changed with the output terminal assignment **(Pr.195, Pr.196)**.
∗8 The function of these terminals can be changed with the output terminal assignment **(Pr.190 to Pr.194).**
∗9 No function is assigned in the initial setting. Use **Pr.192** for function assignment.
∗10 The terminal FM can be used to output pulse trains as open collector output by setting **Pr.291**.
∗11 Not required when calibrating the scale with the operation panel.

**NOTE**

- To prevent a malfunction due to noise, keep the signal cables 10 cm or more away from the power cables. Also, separate the main circuit cables at the input side from the main circuit cables at the output side.
- After wiring, wire offcuts must not be left in the inverter.
  Wire offcuts can cause an alarm, failure or malfunction. Always keep the inverter clean.
  When drilling mounting holes in an enclosure etc., take caution not to allow chips and other foreign matter to enter the inverter.
- Set the voltage/current input switch correctly. Incorrect setting may cause a fault, failure or malfunction.

## ◆CA type


Sourse logic
Main circuit terminal
Control circuit terminal
Brake unit (Option)
Converter unit
R/L1
S/L2
T/L3
P/+
N/-
Jumper *1
R1/L11
S1/L21
Earth (Ground)
Main circuit
Control circuit
U
V
W
Motor
M
Earth (Ground)
RDI
OH
RES
SD
PC
+24
C1
B1
A1
RDB
RDA
RSO
IPF
FAN
SE
Control input signals (No voltage input allowed) *2
Forward rotation start
Reverse rotation start
Start self-holding selection
Multi-speed selection
High speed
Middle speed
Low speed
Jog operation
Second function selection
Output stop
Reset
Terminal 4 input selection
Selection of automatic restart after instantaneous power failure
Common for external power supply transistor
Contact input common 24VDC power supply
STF
STR
STP(STOP)
RH
RM
RL
JOG *3
RT
MRS
X10 *4
RES
AU
CS
SD
PC
SOURCE
SINK
24V
Relay output *7
C1
B1
A1
Relay output 1 (Fault output)
C2
B2
A2
Relay output 2
Open collector output *8
RUN
Running
SU
Up to frequency
IPF
*9
OL
Overload
FU
Frequency detection
SE
Open collector output common
Sink/source common
24V external power supply input
Common terminal
+24
SD
*5 Voltage/current input switch
PU connector
USB A connector
USB mini B connector
F/C (CA)
(+)
(-)
Analog current output (0 to 20mADC)
AM
5
Analog signal output (0 to ±10VDC)
Frequency setting signals (Analog)
10E(+10V)
10(+5V)
ON
OFF
2 4
Frequency setting potentiometer 1/2W1kΩ *6
0 to 5VDC Initial value
0 to 10VDC
0 to 20mADC
selectable *5
(Analog common)
Auxiliary input
0 to ±10VDC Initial value
(0 to ±5VDC selectable) *5
Terminal 4 input (Current input)
4 to 20mADC Initial value
(0 to 5VDC
0 to 10VDC
selectable) *5
RS-485 terminals
TXD+
TXD-
Data transmission
RXD+
RXD-
Data reception
SG
GND
Terminating resistor
VCC
5V (Permissible load current 100mA)
Connector for plug-in option connection
connector 1
connector 2
connector 3
Safety stop signal
Shorting wire
24V
PC
S1
S2
SIC
SD
Safety stop input (Channel 1)
Safety stop input (Channel 2)
Safety stop input common
Output shutoff circuit
So
SOC
Safety monitor output
Safety monitor output common

∗1 The terminals R1/L11 and S1/L21 are connected to the terminals P/+ and N/- with a jumper respectively. When using separate power supply for the control circuit, remove the jumpers from R1/L11 and S1/L21.
∗2 The function of these terminals can be changed with the input terminal assignment **(Pr.178 to Pr.189)**.
∗3 Terminal JOG is also used as the pulse train input terminal. Use **Pr.291** to choose JOG or pulse.
∗4 The X10 signal (NC contact input specification) is assigned to the terminal MRS in the initial setting. Set **Pr.599** = "0" to change the input specification of the X10 signal to NO contact.
∗5 Terminal input specifications can be changed by analog input specification switchover **(Pr.73, Pr.267).** To input a voltage (0 to 5 V/0 to 10 V), set the voltage/current input switch OFF. To input a current (4 to 20 mA), set the voltage/current input switch ON. Terminals 10 and 2 are also used as a PTC input terminal. **(Pr.561)**
∗6 It is recommended to use 2 W 1 kΩ when the frequency setting signal is changed frequently.
∗7 The function of these terminals can be changed with the output terminal assignment **(Pr.195, Pr.196)**.
∗8 The function of these terminals can be changed with the output terminal assignment **(Pr.190 to Pr.194).**
∗9 No function is assigned in the initial setting. Use **Pr.192** for function assignment.

**NOTE**

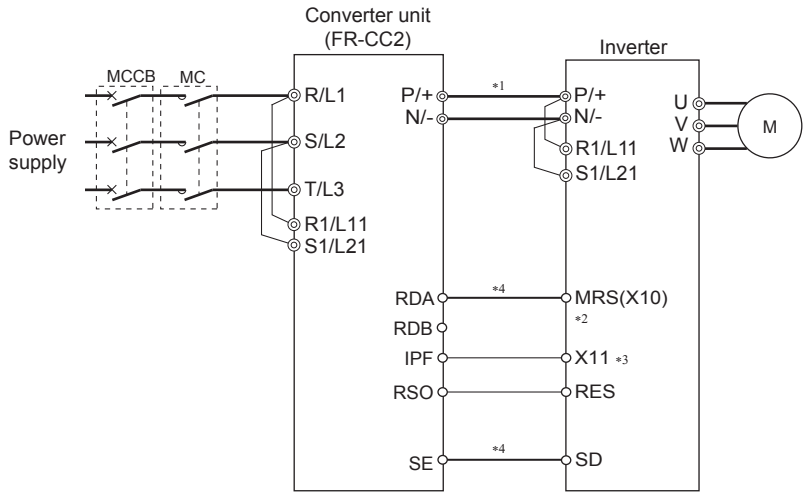
- To prevent a malfunction due to noise, keep the signal cables 10 cm or more away from the power cables. Also, separate the main circuit cables at the input side from the main circuit cables at the output side.
- After wiring, wire offcuts must not be left in the inverter.
  Wire offcuts can cause an alarm, failure or malfunction. Always keep the inverter clean.
  When drilling mounting holes in an enclosure etc., take caution not to allow chips and other foreign matter to enter the inverter.
- Set the voltage/current input switch correctly. Incorrect setting may cause a fault, failure or malfunction.

## ◆Connection between the converter unit and the inverter

Perform wiring so that the commands sent from the converter unit are transmitted to the inverter without fail. Incorrect connection may damage the converter unit and the inverter.
For the wiring length, refer to the table below.

| | | |
|---|---|---|
| Total wiring length | Across the terminals P and P and the terminals N and N | 50 m or lower |
| | Other control signal cables | 30 m or lower |

For the cable gauge of the cable across the main circuit terminals P/+ and N/- (P and P, N and N), refer to **page 30**.




∗1 Do not install an MCCB across the terminals P/+ and N/- (across terminals P and P/+ or across N and N/-). Connecting the opposite polarity of terminals N/- and P/+ will damage the inverter.
∗2 For the terminal used for the X10 signal input, set "10" in any of **Pr.178 to Pr.189 (input terminal function selection)** to assign the function. (The X10 signal is assigned to the terminal MRS in the initial setting.)
For the X10 signal, NC contact input specification is selected in the initial setting. Set **Pr.599** = "0" to change the input specification to NO contact.
∗3 For the terminal used for the X11 signal input, set "11" in any of **Pr.178 to Pr.189 (input terminal function selection)** to assign the function. For RS-485 or any other communication where the start command is only transmitted once, use the X11 signal to save the operation mode at the time of an instantaneous power failure.
∗4 Always connect the terminal RDA of the converter unit and the terminal MRS (X10) of the inverter, and the terminal SE of the converter unit and the terminal SD (sink logic) of the inverter. Not connecting these terminals may damage the converter unit.

# 2.5 Main circuit terminals

## 2.5.1 Details on the main circuit terminals of the inverter

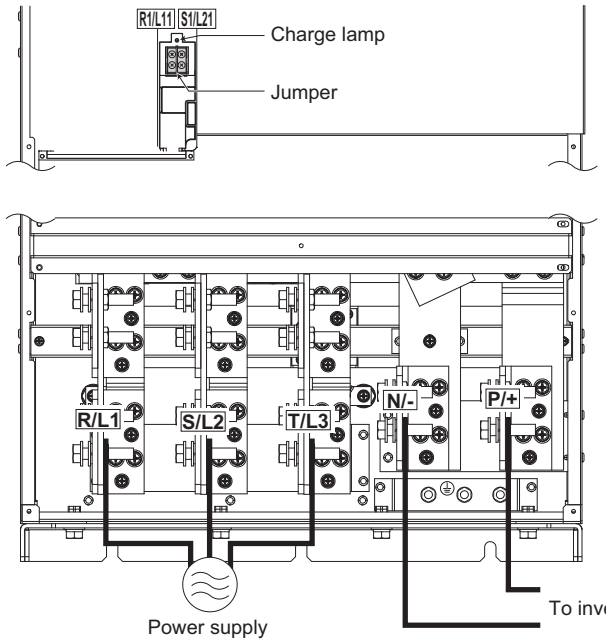
| Terminal symbol | Terminal name | Terminal function description | Refer to page |
|---|---|---|---|
| U, V, W | Inverter output | Connect these terminals to a three-phase squirrel cage motor or an PM motor. | - |
| R1/L11, S1/L21 | Power supply for the control circuit | Connected to the terminals P/+ and N/-. To retain the fault display and fault output, or to use the converter unit (FR-CC2), remove the jumpers installed in terminals R1/L11 and S1/L21, and apply external power supply to these terminals.<br>The power capacity necessary when separate power is supplied from R1/L11 and S1/L21 is 80 VA. | 43 |
| P/+, N/- | Converter unit connection | Connect the converter unit (FR-CC2), brake unit (FR-BU2), or high power factor converter (FR-HC2). | 24, 57 |
| ⏚ | Earth (ground) | For earthing (grounding) the inverter chassis. This must be earthed (grounded). | 32 |

## 2.5.2 Details on the main circuit terminals of the converter unit (FR-CC2)

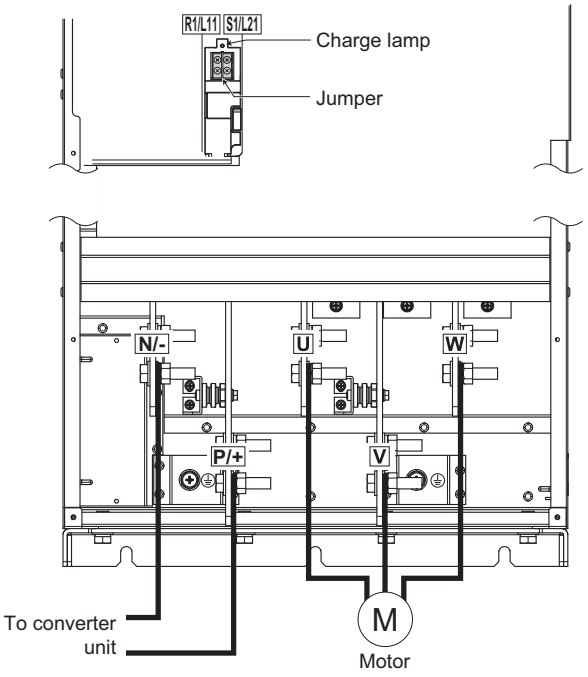
| Terminal symbol | Terminal name | Terminal function description | Refer to page |
|---|---|---|---|
| R/L1, S/L2, T/L3 | AC power input | Connect these terminals to the commercial power supply. | - |
| R1/L11, S1/L21 | Power supply for the control circuit | Connected to the AC power supply terminals R/L1 and S/L2. To retain the fault display and fault output, remove the jumpers across terminals R/L1 and R1/L11 and across S/L2 and S1/L21, and supply external power to these terminals.<br>The power capacity necessary when separate power is supplied from R1/L11 and S1/L21 is 80 VA. | 43 |
| P/+, N/- | Inverter connection | Connect to terminals P/+ and N/- of the inverter. | 24 |
| ⏚ | Earth (ground) | For earthing (grounding) the converter unit chassis. This must be earthed (grounded). | 32 |

# 2.5.3 Terminal layout of the main circuit terminals, wiring of power supply and the motor

FR-CC2-315K to FR-CC2-500K

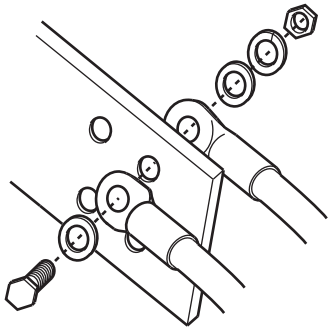



FR-A842-07700(315K) to FR-A842-12120(500K)



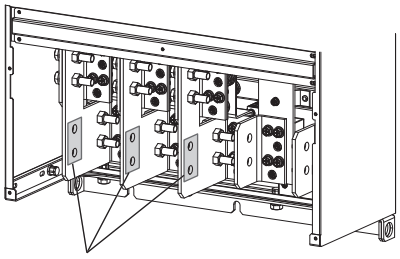

**NOTE**

- Make sure the power cables are connected to the R/L1, S/L2, and T/L3 of the converter unit. (Phase need not be matched.) Never connect the power cable to the U, V, and W of the inverter. Doing so will damage the inverter.
- Connect the motor to the U, V, and W of the inverter. (The phases must be matched.)
- When wiring the main circuit conductor, tighten a nut from the right side of the conductor. When wiring two wires, place wires on both sides of the conductor. (Refer to the diagram below.) For wiring, use bolts (nuts) provided with the inverter.



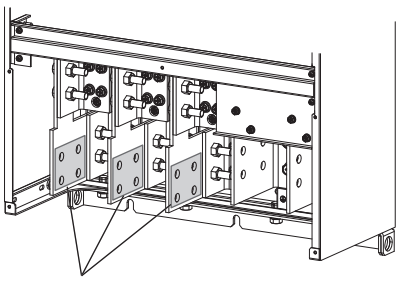
- When wiring the main circuit conductor (R/L1, S/L2, T/L3) of the converter unit (FR-CC2), use the bolts (nuts) for main circuit wiring, which are provided on the front side of the conductor.

**FR-CC2-H315K, H355K**



Connect the cables here.

**FR-CC2-H400K to H500K**



Connect the cables here.

# 2.5.4 Applicable cables and wiring length

Select a recommended cable size to ensure that the voltage drop will be 2% or less.
If the wiring distance is long between the inverter and motor, the voltage drop in the main circuit will cause the motor torque to decrease especially at a low speed.
The following table indicates a selection example for the wiring length of 20 m (440 V input power supply, 150% overload current rating for 1 minute).

• Converter unit (FR-CC2)

| Converter model FR-CC2-[ ] | Terminal screw Size*4 | Tightening Torque N·m | Crimping terminal | Cable gauge | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | HIV cables, etc. ($mm^2$)*1 | | | AWG/MCM *2 | PVC cables, etc. ($mm^2$)*3 | |
| | | | R/L1, S/L2, T/L3 | R/L1, S/L2, T/L3 | P/+, N/- | Earthing (grounding) cable | R/L1, S/L2, T/L3 | R/L1, S/L2, T/L3 | Earthing (grounding) cable |
| 315K | M12 (M10) | 46 | 150-12 | 2×150 | 2×150 | 100 | 2×300 | 2×150 | 150 |
| 355K | M12 (M10) | 46 | C2-200 | 2×200 | 2×200 | 100 | 2×350 | 2×185 | 2×95 |
| 400K | M12 (M10) | 46 | C2-200 | 2×200 | 2×200 | 100 | 2×400 | 2×185 | 2×95 |
| 450K | M12 (M10) | 46 | C2-250 | 2×250 | 2×250 | 100 | 2×500 | 2×240 | 2×120 |
| 500K | M12 (M10) | 46 | C2-200 | 3×200 | 3×200 | 2×100 | 2×500 | 2×240 | 2×120 |

• Inverter

| Inverter model FR-A840-[ ] | Terminal screw size*4 | Tightening Torque N·m | Crimping terminal | Cable gauge | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | HIV cables, etc. ($mm^2$)*1 | | | AWG/MCM*2 | PVC cables, etc. ($mm^2$)*3 | |
| | | | U, V, W | U, V, W | P/+, N/- | Earthing (grounding) cable | U, V, W | U, V, W | Earthing (grounding) cable |
| 07700(315K) | M12 (M10) | 46 | 150-12 | 2×150 | 2×150 | 100 | 2×300 | 2×150 | 150 |
| 08660(355K) | M12 (M10) | 46 | C2-200 | 2×200 | 2×200 | 100 | 2×350 | 2×185 | 2×95 |
| 09620(400K) | M12 (M10) | 46 | C2-200 | 2×200 | 2×200 | 100 | 2×400 | 2×185 | 2×95 |
| 10940(450K) | M12 (M10) | 46 | C2-250 | 2×250 | 2×250 | 100 | 2×500 | 2×240 | 2×120 |
| 12120(500K) | M12 (M10) | 46 | C2-250 | 2×250 | 3×200 | 2×100 | 2×500 | 2×240 | 2×120 |

*1 The gauge of the cable with the continuous maximum permissible temperature of 90°C or higher. (LMFC (heat resistant flexible cross-linked polyethylene insulated cable), etc.). It assumes a surrounding air temperature of 40°C or lower and in-enclosure wiring.

*2 The recommended cable size is that of the cable (THHN cable) with continuous maximum permissible temperature of 90°C. It assumes a surrounding air temperature of 40°C or lower and in-enclosure wiring.
(Selection example for use mainly in the United States.)

*3 The cable size is that of the cable (XLPE cable) with continuous maximum permissible temperature of 90°C. It assumes a surrounding air temperature of 40°C or lower and in-enclosure wiring.
(Selection example for use mainly in Europe.

*4 The terminal screw size indicates the size of a terminal screw for R/L1, S/L2, T/L3, U, V, W, P/+, N/-, and a screw for earthing (grounding). Screw size for earthing (grounding) is indicated in parentheses.

The line voltage drop can be calculated by the following formula:

$$\text{Line voltage drop [V]} = \frac{\sqrt{3} \times \text{wire resistance[m}\Omega\text{/m]} \times \text{wiring distance[m]} \times \text{current[A]}}{1000}$$

Use a larger diameter cable when the wiring distance is long or when it is desired to decrease the voltage drop (torque reduction) in the low speed range.

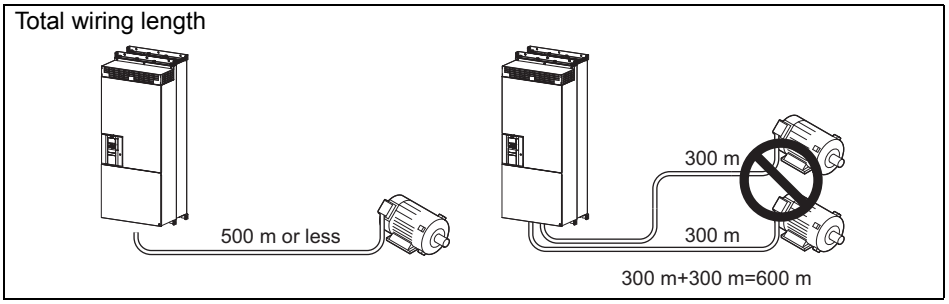
**NOTE**

- Tighten the terminal screw to the specified torque.
  A screw that has been tightened too loosely can cause a short circuit or malfunction.
  A screw that has been tightened too tightly can cause a short circuit or malfunction due to the unit breakage.
- Use crimping terminals with insulation sleeves to wire the power supply and motor.

# ◆Total wiring length

## ◆With induction motor

Connect one or more general-purpose motors within the total wiring length 500 m. (The wiring length should be 100 m or less under vector control.)




When driving a 400 V class motor by the inverter, surge voltages attributable to the wiring constants may occur at the motor terminals, deteriorating the insulation of the motor. In this case, take one of the following measure.

- Use a "400 V class inverter-driven insulation-enhanced motor" and set **Pr.72 PWM frequency selection** according to the wiring length.

| Wiring length 100 m or shorter | Wiring length longer than 100 m |
|---|---|
| 6 (6 kHz) or lower | 4 (4 kHz) or lower |

- If the motor capacity is 280 kW or lower, connect the sine wave filter (MT-BSL/BSC) to the output side.

## ◆With PM motor

Use the wiring length of 100 m or shorter when connecting a PM motor.

Use one PM motor for one inverter. Multiple PM motors cannot be connected to an inverter.

When the wiring length exceeds 50 m for a 400 V class motor driven by an inverter under PM sensorless vector control, set "9" (6 kHz) or less in **Pr.72 PWM frequency selection**.

NOTE

- Especially for long-distance wiring, the inverter may be affected by a charging current caused by the stray capacitances of the wiring, leading to a malfunction of the overcurrent protective function or fast response current limit function or a malfunction or fault of the equipment connected on the inverter output side. If the fast-response current limit function malfunctions, disable this function. (For the details of **Pr.156 Stall prevention operation selection**, refer to the FR-A800 Instruction Manual (Detailed))
- A sine wave filter (MT-BSL/BSC) can be used under V/F control. Do not use the filters under different control methods.
- For the details of **Pr.72 PWM frequency selection**, refer to the FR-A800 Instruction Manual (Detailed).
- Refer to page 72 to drive a 400 V class motor by an inverter.
- The carrier frequency is limited during PM sensorless vector control. (Refer to the FR-A800 Instruction Manual (Detailed))

# 2.5.5 Earthing (grounding) precautions

- Always earth (ground) the motor, the inverter, and the converter unit.

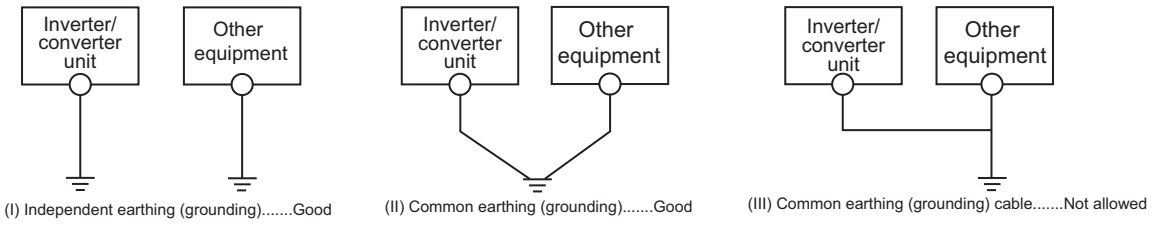
## ◆Purpose of earthing (grounding)

Generally, an electrical apparatus has an earth (ground) terminal, which must be connected to the ground before use.
An electrical circuit is usually insulated by an insulating material and encased. However, it is impossible to manufacture an insulating material that can shut off a leakage current completely, and actually, a slight current flows into the case. The purpose of earthing (grounding) the case of an electrical apparatus is to prevent operators from getting an electric shock from this leakage current when touching it.
To avoid the influence of external noises, this earthing (grounding) is important to audio equipment, sensors, computers and other apparatuses that handle low-level signals or operate very fast.

## ◆Earthing (grounding) methods and earthing (grounding) work

As described previously, earthing (grounding) is roughly classified into an electrical shock prevention type and a noise-influenced malfunction prevention type. Therefore, these two types should be clearly distinguished, and the following work must be done to prevent the leakage current having the inverter's high frequency components from entering the malfunction prevention type earthing (grounding):

- Whenever possible, use the independent earthing (grounding) for the inverter.
  If independent earthing (grounding) (I) is not available, use (II) common earthing (grounding) in the figure below where the inverter is connected with the other equipment at an earthing (grounding) point. Do not use the other equipment's earthing (grounding) cable to earth (ground) the inverter as shown in (III).
  A leakage current containing many high frequency components flows into the earthing (grounding) cables of the inverter and peripheral devices. Because of this, the inverter must be earthed (grounded) separately from EMI-sensitive devices.
  In a high building, it may be effective to use the EMI prevention type earthing (grounding) connecting to an iron structure frame, and electric shock prevention type earthing (grounding) with the independent earthing (grounding) together.
  - Earthing (Grounding) must conform to the requirements of national and local safety regulations and electrical codes. (NEC section 250, IEC 536 class 1 and other applicable standards).
    A neutral-point earthed (grounded) power supply in compliance with EN standard must be used.
  - use the thickest possible earthing (grounding) cable. The earthing (grounding) cable should be the size indicated in the table on page 30.
  - The earthing (grounding) point should be as close as possible to the inverter, and the earth (ground) wire length should be as short as possible.
  - Run the earthing (grounding) cable as far away as possible from the I/O wiring of equipment sensitive to noises and run them in parallel in the minimum distance.




(I) Independent earthing (grounding).....Good (II) Common earthing (grounding).....Good (III) Common earthing (grounding) cable.....Not allowed

To be compliant with the EU Directive (Low Voltage Directive), refer to page 109.

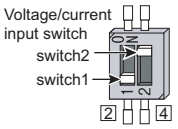
# 2.6 Control circuit

## 2.6.1 Details on the control circuit terminals of the inverter

The input signal function of the terminals in [ ] can be selected by setting **Pr.178 to Pr.196 (I/O terminal function selection)**.
For the parameter details, refer to the FR-A800 Instruction Manual (Detailed).

### ◆Input signal

| Type | Terminal Symbol | Terminal name | Terminal function description | | Rate Specification |
|---|---|---|---|---|---|
| Contact input | STF | Forward rotation start | Turn ON the STF signal to start forward rotation and turn it OFF to stop. | When the STF and STR signals are turned ON simultaneously, the stop command is given. | Input resistance 4.7 kΩ<br>Voltage when contacts are open: 21 to 27 VDC<br>When contacts are short-circuited: 4 to 6 mADC |
| | STR | Reverse rotation start | Turn ON the STR signal to start reverse rotation and turn it OFF to stop. | | |
| | STOP | Start self-holding selection | Turn ON the STOP signal to self-hold the start signal. | | |
| | RH<br>RM<br>RL | Multi-speed selection | Multi-speed can be selected according to the combination of RH, RM and RL signals. | | |
| | JOG | Jog mode selection | Turn ON the JOG signal to enable JOG operation (initial setting) and turn ON the start signal (STF or STR) to start JOG operation. | | |
| | | Pulse train input | Terminal JOG is also used as the pulse train input terminal. To use as a pulse train input terminal, change the **Pr.291** setting.<br>(maximum input pulse: 100k pulses/s) | | Input resistance 2 kΩ<br>When contacts are short-circuited: 8 to 13 mADC |
| | RT | Second function selection | Turn ON the RT signal to enable the second function.<br>When the second function such as "second torque boost" and "second V/F (base frequency)" is set, turning ON the RT signal enables the selected function. | | Input resistance 4.7 kΩ<br>Voltage when contacts are open: 21 to 27 VDC<br>When contacts are short-circuited: 4 to 6 mADC |
| | MRS<br>(X10) | Output stop (Inverter operation enable) | Connect to the terminal RDA of the converter unit (FR-CC2). When the RDA signal is turned OFF, the inverter output is shut off.<br>The X10 signal (NC contact) is assigned to the terminal MRS in the initial setting. Use **Pr.599** to change the specification to NO contact. | | |
| | RES | Reset | Use this signal to reset a fault output provided when a protective function is activated. Turn ON the RES signal for 0.1s or longer, then turn it OFF.<br>In the initial setting, reset is always enabled. By setting **Pr.75**, reset can be enabled only at an inverter fault occurrence. The inverter recovers about 1s after the reset is released. | | |
| | AU | Terminal 4 input selection | The terminal 4 function is available only when the AU signal is ON Turning ON the AU signal disables the terminal 2 function. | | |
| | CS | Selection of automatic restart after instantaneous power failure | When the CS signal is left ON, the inverter restarts automatically at power restoration. Note that restart setting is necessary for this operation. In the initial setting, a restart is disabled. | | |
| | SD | Contact input common (sink)*2 | Common terminal for contact input terminal (sink logic) and terminal FM | | ——— |
| | | External transistor common (source)*3 | Connect this terminal to the power supply common terminal of a transistor output (open collector output) device, such as a programmable controller, in the source logic to avoid malfunction by undesirable current. | | |
| | | 24 VDC power supply common | Common terminal for the 24 VDC power supply (terminal PC, terminal +24)<br>Isolated from terminals 5 and SE. | | |
| | PC | External transistor common (sink)*2 | Connect this terminal to the power supply common terminal of a transistor output (open collector output) device, such as a programmable controller, in the source logic to avoid malfunction by undesirable current. | | Power supply voltage range 19.2 to 28.8 VDC<br>Permissible load current 100 mA |
| | | Contact input common (source)*3 | Common terminal for contact input terminal (source logic). | | |
| | | 24 VDC power supply common | Can be used as a 24 VDC 0.1 A power supply. | | |

| Type | Terminal Symbol | Terminal name | Terminal function description | Rate Specification |
|---|---|---|---|---|
| Frequency setting | 10E | Frequency setting power supply | When connecting the frequency setting potentiometer at an initial status, connect it to the terminal 10.<br>Change the input specifications of the terminal 2 in **Pr.73** when connecting it to the terminal 10E. | 10 VDC ±0.4 V<br>Permissible load current 10 mA |
| | 10 | | | 5 VDC ±0.5 V<br>Permissible load current 10 mA |
| | 2 | Frequency setting (voltage) | Inputting 0 to 5 VDC (or 0 to 10 V, 0 to 20 mA) provides the maximum output frequency at 5 V (10 V, 20 mA) and makes input and output proportional. Use **Pr.73** to switch among input 0 to 5 VDC (initial setting), 0 to 10 VDC, and 0 to 20 mA. Set the voltage/current input switch in the ON position to select current input (0 to 20 mA).*1 | When voltage is input:<br>Input resistance 10 kΩ ±1 kΩ<br>Maximum permissible voltage 20 VDC<br>When current is input:<br>Input resistance 245 Ω ±5 Ω<br>Permissible maximum current 30 mA<br>  |
| | 4 | Frequency setting (current) | Inputting 4 to 20 mADC (or 0 to 5 V, 0 to 10 V) provides the maximum output frequency at 20 mA and makes input and output proportional. This input signal is valid only when the AU signal is ON (terminal 2 input is invalid). Use **Pr.267** to switch among input 4 to 20 mA (initial setting), 0 to 5 VDC, and 0 to 10 VDC. Set the voltage/current input switch in the OFF position to select voltage input (0 to 5 V/0 to 10 V).*1<br>Use **Pr.858** to switch terminal functions. | |
| | 1 | Frequency setting auxiliary | Inputting 0 to ±5 VDC or 0 to ±10 VDC adds this signal to terminal 2 or 4 frequency setting signal. Use **Pr.73** to switch between input 0 to ±5 VDC and 0 to ±10 VDC (initial setting). Use **Pr.868** to switch terminal functions. | Input resistance 10 kΩ ±1 kΩ<br>Permissible maximum voltage ±20 VDC |
| | 5 | Frequency setting common | Common terminal for frequency setting signal (terminal 2, 1 or 4) and analog output terminal AM. Do not earth (ground). | ——— |
| Thermistor | 10<br>2 | PTC thermistor input | For receiving PTC thermistor outputs.<br>When PTC thermistor is valid (**Pr.561** ≠ "9999"), the terminal 2 is not available for frequency setting. | Applicable PTC thermistor specification<br>Overheat detection resistance:<br>0.5 to 30 kΩ<br>(Set by **Pr.561**) |
| Power supply input | +24 | 24 V external power supply input | For connecting a 24 V external power supply.<br>If a 24 V external power supply is connected, power is supplied to the control circuit while the main power circuit is OFF. | Input voltage 23 to 25.5 VDC<br>Input current 1.4 A or less |

*1 Set **Pr.73, Pr.267**, and the voltage/current input switch correctly, then input an analog signal in accordance with the setting.
Applying a voltage with the voltage/current input switch ON (current input is selected) or a current with the switch OFF (voltage input is selected) could cause component damage of the inverter or analog circuits of output devices. (For the details, refer to the FR-A800 Instruction Manual (Detailed).)

*2 The sink logic is initially set for the FM-type inverter.

*3 The source logic is initially set for the CA-type inverter.

## ◆Output signal

| Type | Terminal Symbol | Terminal name | Terminal function description | Rate Specification |
|---|---|---|---|---|
| Relay | A1, B1, C1 | Relay output 1 (fault output) | 1 changeover contact output that indicates that an inverter's protective function has been activated and the outputs are stopped.<br>Fault: discontinuity across B and C (continuity across A and C), Normal: continuity across Band C (discontinuity across A and C) | Contact capacity 230 VAC 0.3 A (power factor = 0.4)<br>30 VDC 0.3 A |
| | A2, B2, C2 | Relay output 2 | 1 changeover contact output | |

| Type | Terminal Symbol | Terminal name | Terminal function description | | Rate Specification |
|---|---|---|---|---|---|
| Open collector | RUN | Inverter running | Switched to LOW when the inverter output frequency is equal to or higher than the starting frequency (initial value 0.5 Hz). Switched to HIGH during stop or DC injection brake operation. | | Permissible load 24 VDC (maximum 27 VDC) 0.1 A (The voltage drop is 2.8 V at maximum while the signal is ON.) LOW is when the open collector output transistor is ON (conducted). HIGH is when the transistor is OFF (not conducted). |
| | SU | Up to frequency | Switched to LOW when the output frequency is within the set frequency range ±10% (initial value). Switched to HIGH during acceleration/ deceleration and at a stop. | Fault code (4 bits) output. | |
| | OL | Overload alarm | Switched to LOW when stall prevention is activated by the stall prevention function. Switched to HIGH when stall prevention is canceled. | | |
| | IPF | Open collector output | No function is assigned in the initial setting. The function can be assigned setting **Pr.192**. | | |
| | FU | Frequency detection | Switched to LOW when the inverter output frequency is equal to or higher than the preset detection frequency, and to HIGH when it is less than the preset detection frequency. | | |
| | SE | Open collector output common | Common terminal for terminals RUN, SU, OL, IPF, FU | | ——— |
| Pulse | FM *1 | For meter | Outputs a selected monitored item (such as output frequency) among several monitored items. The signal is not output during an inverter reset. The output signal is proportional to the magnitude of the corresponding monitoring item. Use **Pr.55**, **Pr.56**, and **Pr.866** to set full scales for the monitored output frequency, output current, and torque. | Output item: Output frequency (initial setting) | Permissible load current 2 mA For full scale 1440 pulses/s |
| | | NPN open collector output | | This terminal can be used for open collector outputs by setting **Pr.291**. | Maximum output pulse: 50k pulses/s Permissible load current: 80 mA |
| Analog | AM | Analog voltage output | | Output item: Output frequency (initial setting) | Output signal 0 to 10 VDC, Permissible load current 1 mA (load impedance 10 kΩ or more) resolution 8 bits |
| | CA *2 | Analog current output | | | Load impedance 200 Ω to 450 Ω Output signal 0 to 20 mADC |

*1 Terminal FM is provided in the FM-type inverter.
*2 Terminal CA is provided in the CA-type inverter.

## ◆Communication

| Type | Terminal symbol | | Terminal name | Terminal function description | |
|---|---|---|---|---|---|
| RS-485 | — | | PU connector | With the PU connector, communication can be made through RS-485. (For connection on a 1:1 basis only) Conforming standard: EIA-485 (RS-485) Transmission format: Multidrop link Communication speed: 4800 to 115200 bps Wiring length: 500 m | |
| | RS-485 terminals | TXD+ | Inverter transmission terminal | The RS-485 terminals enable the communication by RS-485. Conforming standard: EIA-485 (RS-485) Transmission format: Multidrop link Communication speed: 300 to 115200 bps Overall length: 500 m | |
| | | TXD- | | | |
| | | RXD+ | Inverter reception terminal | | |
| | | RXD- | | | |
| | | SG | Earthing (grounding) | | |
| USB | — | | USB A connector | A connector (receptacle) A USB memory device enables parameter copies and the trace function. | Interface: Conforms to USB1.1 (USB2.0 fullspeed compatible) Transmission speed: 12 Mbps |
| | | | USB B connector | Mini B connector (receptacle) Connected to a personal computer via USB to enable setting, monitoring, test operations of the inverter by FR Configurator2. | |

## ◆Safety stop signal

For the safety stop function, refer to page 45.

| Terminal Symbol | Terminal name | Terminal function description | Rate Specification |
|---|---|---|---|
| S1 | Safety stop input (Channel 1) | The terminals S1 and S2 are used for the safety stop input signal for the safety relay module. The terminals S1 and S2 are used at the same time (dual channel).<br>Inverter output is shutoff by shortening/opening between terminals S1 and SIC, or between S2 and SIC.<br>In the initial status, terminal S1 and S2 are shorted with the terminal PC by shorting wires. The terminal SIC is shorted with the terminal SD.<br>Remove the shorting wires and connect the safety relay module when using the safety stop function. | Input resistance 4.7 kΩ<br>Input current 4 to 6 mADC (with 24 VDC input) |
| S2 | Safety stop input (Channel 2) | | |
| SIC | Safety stop input terminal common | Common terminal for terminals S1 and S2. | ——— |
| SO | Safety monitor output Open collector output | Indicates the safety stop input signal status.<br>Switched to LOW when the status is other than the internal safety circuit failure. Switched to HIGH during the internal safety circuit failure status.<br>LOW is when the open collector output transistor is ON (conducted).<br>HIGH is when the transistor is OFF (not conducted).<br>Refer to the Safety stop function instruction manual (BCNA23228-001) when the signal is switched to HIGH while both terminals S1 and S2 are open. (Please contact your sales representative for the manual.) | permissible load 24 VDC (27 VDC at maximum), 0.1 A<br>(The voltage drop is 3.4 V at maximum while the signal is ON.) |
| SOC | Safety monitor output terminal common | Common terminal for terminal SO. | ——— |

# 2.6.2 Details on the control circuit terminals of the converter unit (FR-CC2)

The input signal function of the terminals in [ ] can be selected by setting **Pr.178, Pr.187, Pr.189 to Pr.195 (I/O terminal function selection)**.
For the parameter details, refer to the FR-CC2 Instruction Manual.

## ◆Input signal

| Type | Terminal Symbol | Terminal name | Terminal function description | Rate Specification |
|---|---|---|---|---|
| Contact input | RES | Reset | Use this signal to reset a fault output provided when a protective function is activated. Turn ON the RES signal for 0.1 s or longer, then turn it OFF. In the initial setting, reset is always enabled. By setting **Pr.75**, reset can be set enabled only at fault occurrence of the converter unit. The inverter recovers about 1s after the reset is released. | Input resistance 4.7 kΩ<br>Voltage when contacts are open: 21 to 27 VDC<br>When contacts are short-circuited: 4 to 6 mADC |
| | OH | External thermal relay input | The external thermal relay input (OH) signal is used when using an external thermal relay or a thermal protector built into the motor to protect the motor from overheating.<br>When the thermal relay is activated, the inverter trips by the external thermal relay operation (E.OHT). | |
| | RDI | Contact input | The function can be assigned by setting **Pr.178**. | |
| | SD | Contact input common (sink) | Common terminal for contact input terminal (sink logic) and terminal FM | ——— |
| | | External transistor common (source) | Connect this terminal to the power supply common terminal of a transistor output (open collector output) device, such as a programmable controller, in the source logic to avoid malfunction by undesirable current. | |
| | | 24 VDC power supply common | Common terminal for the 24 VDC power supply (terminal PC, terminal +24)<br>Isolated from terminals 5 and SE. | |
| | PC | External transistor common (sink) | Connect this terminal to the power supply common terminal of a transistor output (open collector output) device, such as a programmable controller, in the source logic to avoid malfunction by undesirable current. | Power supply voltage range 19.2 to 28.8 VDC<br>Permissible load current 100 mA |
| | | Contact input common (source) | Common terminal for contact input terminal (source logic). | |
| | | 24 VDC power supply common | Can be used as a 24 VDC 0.1 A power supply. | |
| Power supply input | +24 | 24 V external power supply input | For connecting a 24 V external power supply.<br>If a 24 V external power supply is connected, power is supplied to the control circuit while the main power circuit is OFF. | Input voltage 23 to 25.5 VDC<br>Input current 1.4 A or less |

## ◆Output signal

| Type | Terminal Symbol | Terminal name | Terminal function description | Rate Specification |
|---|---|---|---|---|
| Relay | A1, B1, C1 | Relay output 1 (fault output) | 1 changeover contact output that indicates that the protective function of the converter unit has been activated and the outputs are stopped. Fault: discontinuity across B and C (continuity across A and C), Normal: continuity across Band C (discontinuity across A and C) | Contact capacity 230 VAC 0.3 A (power factor = 0.4) 30 VDC 0.3 A |
| | 88R, 88S | For manufacturer setting. Do not use. | | |
| Open collector | RDA | Inverter operation enable (NO contact) | Switched to LOW when the converter unit operation is ready. Assign the signal to the terminal MRS (X10) of the inverter. The inverter can be started when the RDA status is LOW. | Permissible load 24 VDC (maximum 27 VDC) 0.1 A (The voltage drop is 2.8 V at maximum while the signal is ON.) LOW is when the open collector output transistor is ON (conducted). HIGH is when the transistor is OFF (not conducted). |
| | RDB | Inverter operation enable (NC contact) | Switched to LOW when a converter unit fault occurs or the converter is reset. The inverter can be started when the RDB status is HIGH. | |
| | RSO | Inverter reset | Switched to LOW when the converter is reset (RES-ON). Assign the signal to the terminal RES of the inverter. The inverter is reset when it is connected with the RSO status LOW. | |
| | IPF | Instantaneous power failure | Switched to LOW when an instantaneous power failure is detected. | |
| | FAN | Cooling fan fault | Switched to LOW when a cooling fan fault occurs. | |
| | SE | Open collector output common | Common terminal for terminals RDA, RDB, RSO, IPF, FAN Connect this terminal to the terminal SD (sink logic) or PC (source logic) of the inverter. | ——— |

### ⚠Caution

- **Do not use the empty terminals (NC) of the control circuit. Doing so may lead to damage of the converter unit and the inverter.**
- **Always connect the terminal RDA of the converter unit and the terminal MRS (X10) of the inverter, and the terminal SE of the converter unit and the terminal SD (terminal PC in the source logic) of the inverter. Not doing so may lead to damage of the converter unit.**

# 2.6.3 Control logic (sink/source) change

Change the control logic of input signals as necessary.

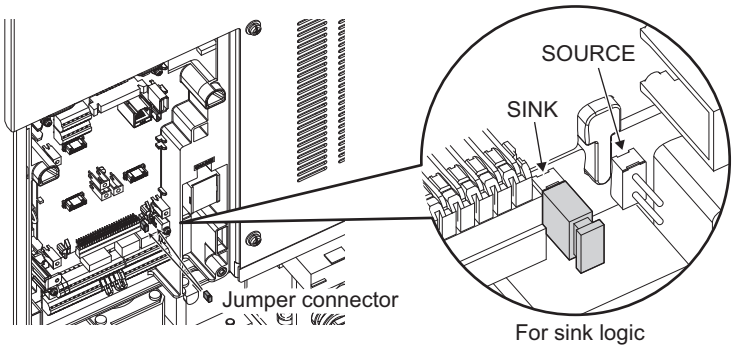
To change the control logic, change the jumper connector position on the control circuit board.

Connect the jumper connector to the connector pin of the desired control logic.

The control logic of input signals is initially set to the sink logic (SINK) for the FM type inverter.

The control logic of input signals is initially set to the source logic (SOURCE) for the CA type inverter.

(The output signals may be used in either the sink or source logic independently of the jumper connector position.)




For sink logic

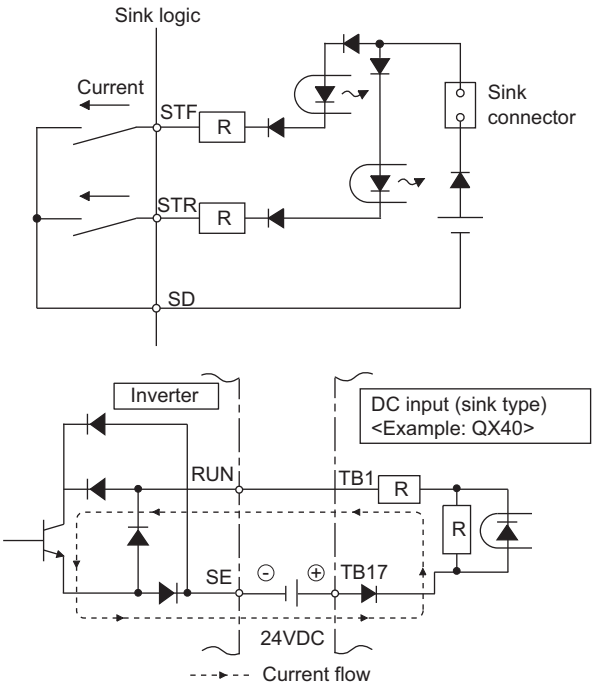
NOTE

- Make sure that the jumper connector is installed correctly.
- Never change the control logic while power is ON.

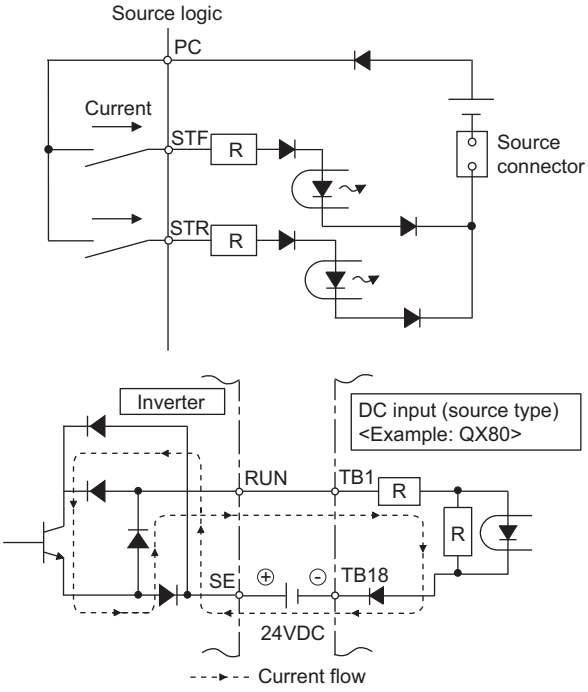
## ◆Sink logic and source logic

- In the sink logic, a signal switches ON when a current flows from the corresponding signal input terminal. Terminal SD is common to the contact input signals. Terminal SE is common to the open collector output signals.
- In the source logic, a signal switches ON when a current flows into the corresponding signal input terminal. Terminal PC is common to the contact input signals. Terminal SE is common to the open collector output signals.

**●Current flow concerning the input/output signal when sink logic is selected**



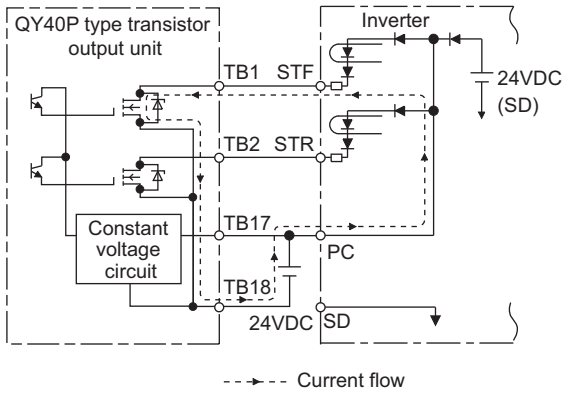

**●Current flow concerning the input/output signal when source logic is selected**




- When using an external power supply for transistor output

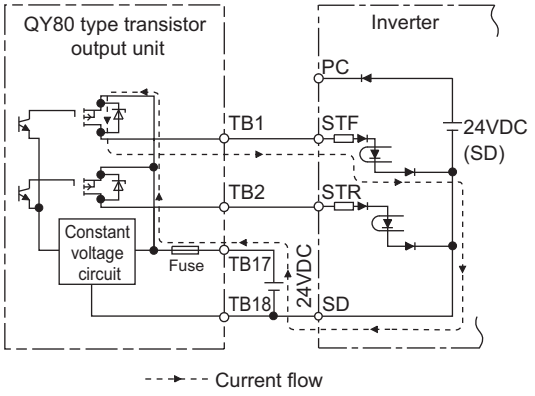
Sink logic

Use the terminal PC as a common terminal, and perform wiring as shown below. (Do not connect terminal SD of the inverter with the terminal 0V of the external power supply. When using terminals PC-SD as a 24 VDC power supply, do not install an external power supply in parallel with the inverter. Doing so may cause a malfunction in the inverter due to undesirable currents.)



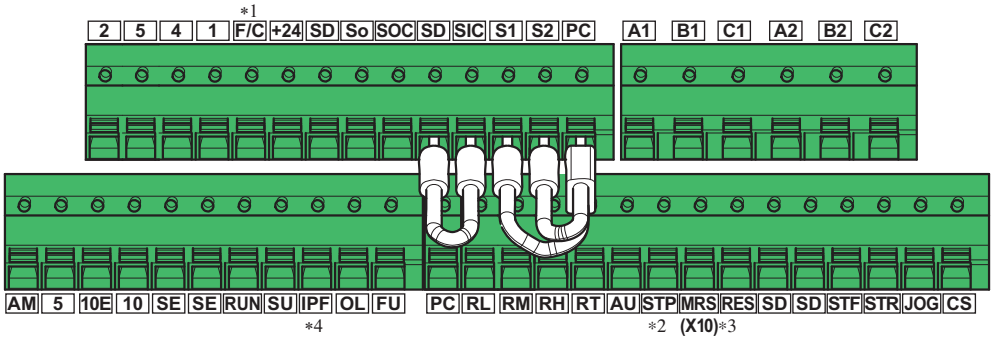

Source logic

Use the terminal SD as a common terminal, and perform wiring as shown below. (Do not connect terminal PC of the inverter with the terminal +24 V of the external power supply. When using terminals PC-SD as a 24 VDC power supply, do not install an external power supply in parallel with the inverter. Doing so may cause a malfunction in the inverter due to undesirable currents.)



# 2.6.4 Wiring of inverter control circuit

## ◆Control circuit terminal layout




*1 This terminal operates as the terminal FM for the FM type, and as the terminal CA for the CA type.
*2 Represents the terminal STOP.
*3 The X10 signal is assigned in the initial setting.
*4 No signal is assigned in the initial setting.

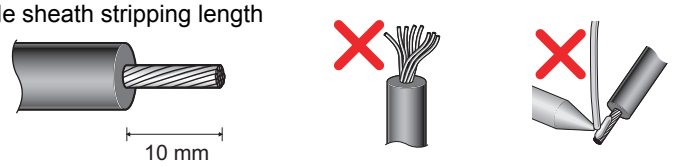
## ◆Wiring method

• Power supply connection

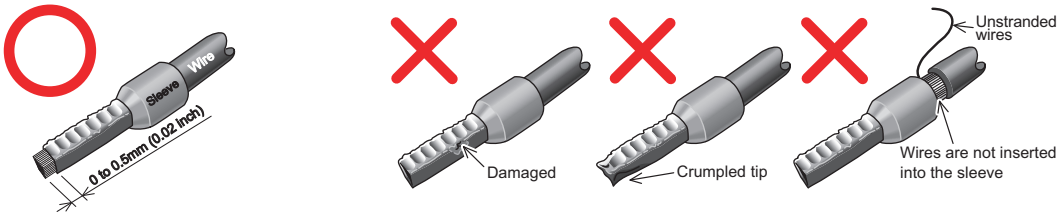
For the control circuit wiring, strip off the sheath of a cable, and use it with a blade terminal. For a single wire, strip off the sheath of the wire and apply directly.
Insert the blade terminal or the single wire into a socket of the terminal.

(1) Strip off the sheath for the below length. If the length of the sheath peeled is too long, a short circuit may occur with neighboring wires. If the length is too short, wires might come off.
Wire the stripped cable after twisting it to prevent it from becoming loose. In addition, do not solder it.

Cable sheath stripping length




(2) Crimp the blade terminal.
Insert wires to a blade terminal, and check that the wires come out for about 0 to 0.5 mm from a sleeve.
Check the condition of the blade terminal after crimping. Do not use a blade terminal of which the crimping is inappropriate, or the face is damaged.




• Blade terminals commercially available (as of February 2012)
Phoenix Contact Co., Ltd.

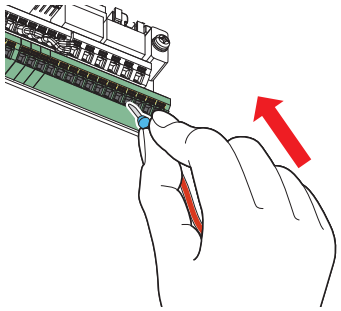
| Cable gauge ($mm^2$) | Blade terminal model | | | Crimping tool name |
|---|---|---|---|---|
| | With insulation sleeve | Without insulation sleeve | For UL wire *1 | |
| 0.3 | AI 0, 5-10WH | - | - | CRIMPFOX 6 |
| 0.5 | AI 0, 5-10WH | - | AI 0, 5-10WH-GB | |
| 0.75 | AI 0, 75-10GY | A 0, 75-10 | AI 0, 75-10GY-GB | |
| 1 | AI 1-10RD | A 1-10 | AI 1-10RD/1000GB | |
| 1.25, 1.5 | AI 1, 5-10BK | A 1, 5-10 | AI 1, 5-10BK/1000GB*2 | |
| 0.75 (for two wires) | AI-TWIN 2 × 0, 75-10GY | - | - | |

*1 A blade terminal with an insulation sleeve compatible with the MTW wire which has a thick wire insulation.
*2 Applicable for the terminals A1, B1, C1, A2, B2, and C2 only.

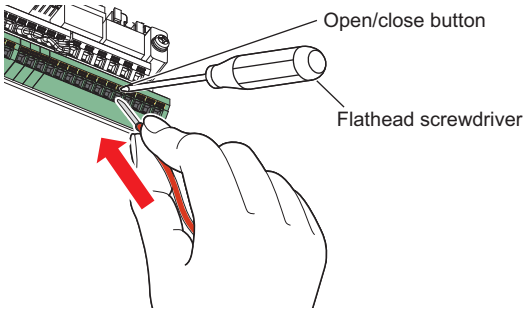
NICHIFU Co.,Ltd.

| Cable gauge ($mm^2$) | Blade terminal product number | Insulation product number | Crimping tool product number |
|---|---|---|---|
| 0.3 to 0.75 | BT 0.75-11 | VC 0.75 | NH 69 |

(3) Insert the wires into a socket.



When using a single wire or stranded wires without a blade terminal, push the open/close button all the way down with a flathead screwdriver, and insert the wire.

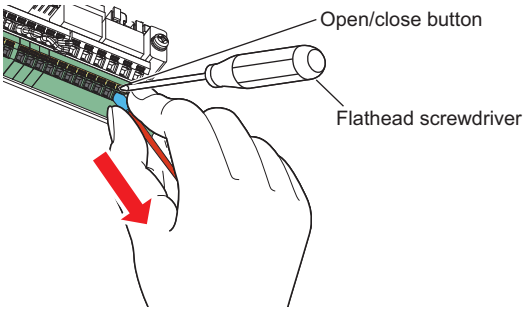



**NOTE**

- When using stranded wires without a blade terminal, twist enough to avoid short circuit with a nearby terminals or wires.
- Never change the control logic while power is ON.

• Wire removal

Pull the wire while pushing the open/close button all the way down firmly with a flathead screwdriver.




**NOTE**

- Pulling out the wire forcefully without pushing the open/close button all the way down may damage the terminal block.
- Use a small flathead screwdriver (tip thickness: 0.4 mm/tip width: 2.5 mm).
  If a flathead screwdriver with a narrow tip is used, terminal block may be damaged.
  Commercially available products (as of February 2012)

| Name | Model | Manufacturer |
|---|---|---|
| Driver | SZF 0- 0,4 × 2,5 | Phoenix Contact Co., Ltd. Contact Co., Ltd. |

- Place the flathead screwdriver vertical to the open/close button. In case the blade tip slips, it may cause an inverter damage or injury.

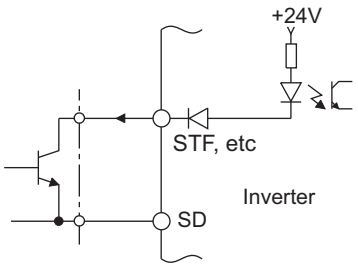
## ◆Common terminals of the control circuit (SD, PC, 5, SE)

- Terminals SD (sink logic), PC (source logic), 5, and SE are common terminals (0V) for I/O signals. (All common terminals are isolated from each other.) Do not earth (ground) these terminals. Avoid connecting the terminal SD (sink logic) with 5, the terminal PC (source logic) with 5, and the terminal SE with 5.
- In the sink logic, terminal SD is a common terminal for the contact input terminals (STF, STR, STOP, RH, RM, RL, JOG, RT, MRS, RES, AU, CS) and the pulse train output terminal (FM*1). The open collector circuit is isolated from the internal control circuit by photocoupler.
- In the source logic, terminal PC is a common terminal for the contact input terminals (STF, STR, STOP, RH, RM, RL, JOG, RT, MRS, RES, AU, CS). The open collector circuit is isolated from the internal control circuit by photocoupler.
- Terminal 5 is a common terminal for the frequency setting terminals (2, 1 or 4) and the analog output terminals (AM, CA*2). It should be protected from external noise using a shielded or twisted cable.
- Terminal SE is a common terminal for the open collector output terminals (RUN, SU, OL, IPF, FU). The contact input circuit is isolated from the internal control circuit by photocoupler.

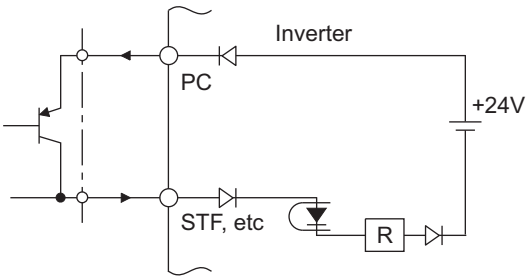
*1 Terminal FM is provided in the FM-type inverter.
*2 Terminal CA is provided in the CA-type inverter.

## ◆Signal inputs by contactless switches

The contact input terminals of the inverter (STF, STR, STOP, RH, RM, RL, JOG, RT, MRS, RES, AU, CS) can be controlled using a transistor instead of a contact switch as shown below.



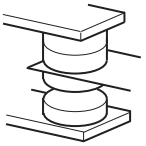

External signal input using transistor (sink logic)



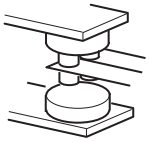

External signal input using transistor (source logic)

# 2.6.5 Wiring precautions

- It is recommended to use a cable of 0.75 $mm^2$ for the connection to the control circuit terminals.
- The wiring length should be 30 m (200 m for the terminal FM) at the maximum.
- Use two or more parallel micro-signal contacts or twin contacts to prevent contact faults when using contact inputs since the control circuit input signals are micro-currents.

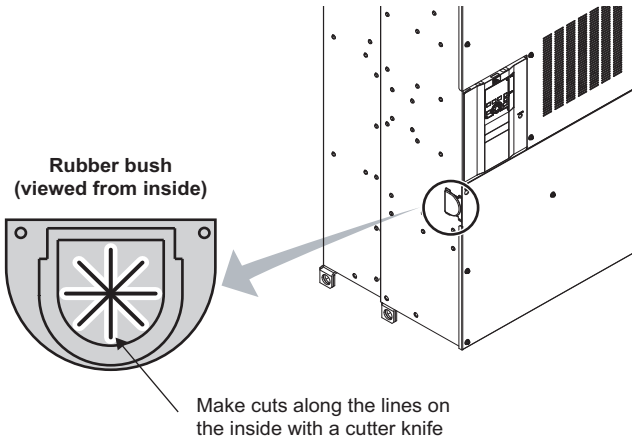


Micro signal contacts

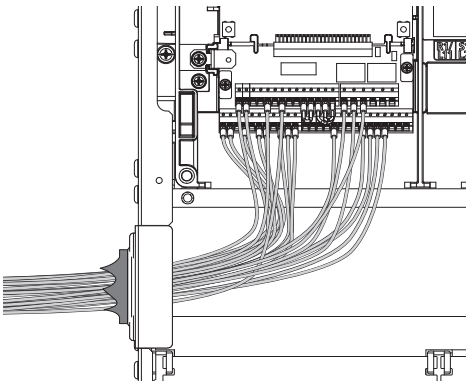


Twin contacts

- To suppress EMI, use shielded or twisted cables for the control circuit terminals and run them away from the main and power circuits (including the 200V relay sequence circuit). For the cables connected to the control circuit terminals, connect their shields to the common terminal of the connected control circuit terminal. When connecting an external power supply to the terminal PC, however, connect the shield of the power supply cable to the negative side of the external power supply. Do not directly earth (ground) the shield to the enclosure, etc.
- Do not apply a voltage to the contact input terminals (STF, etc.) of the control circuit.
- Always apply a voltage to the fault output terminals (A1, B1, C1, A2, B2, C2) via a relay coil, lamp, etc.
- Separate the wiring of the control circuit away from the wiring of the main circuit.
  Make cuts in rubber bush of the inverter side and lead the wires through.




**<Wiring example>**



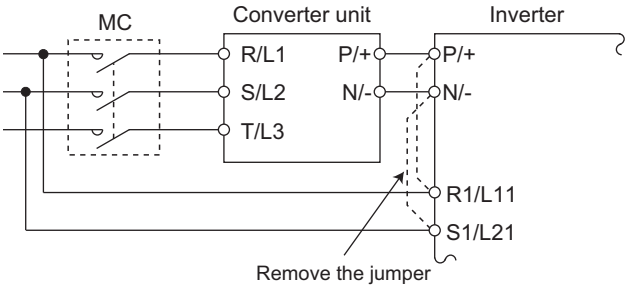
# 2.6.6 When using separate power supplies for the control circuit and the main circuit

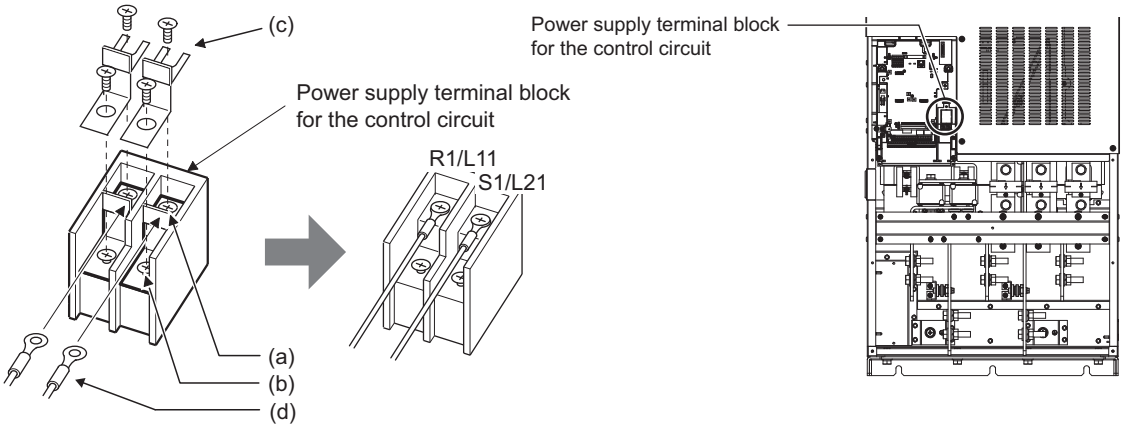
## ◆Cable size for the control circuit power supply (terminals R1/L11 and S1/L21)

- Terminal screw size: M4
- Cable gauge: 0.75 $mm^2$ to 2 $mm^2$
- Tightening torque: 1.5 N·m

## ◆Connected to

When a fault occurs, opening of the electromagnetic contactor (MC) on the inverter power supply side results in power loss in the control circuit, disabling the fault output signal retention. Terminals R1/L11 and S1/L21 are provided to hold a fault signal. In this case, connect the power supply terminals R1/L11 and S1/L21 of the control circuit to the input side of the MC.
The terminals R1/L11 and S1/L21 are connected to the terminals P/+ and N/- with a jumper respectively. Do not connect the power cable to incorrect terminals. Doing so may damage the inverter.
<Connection diagram>




(a) Remove the upper screws.
(b) Remove the lower screws.
(c) Pull the jumper toward you to remove.
(d) Connect the separate power supply cable for the control circuit to the upper terminals (R1/L11, S1/L21).

**NOTE**

- When using separate power supplies, always remove the jumpers from terminals R1/L11 and S1/L21. The inverter may be damaged if the jumpers are not removed.
- The voltage should be the same as that of the main control circuit when the control circuit power is supplied from other than the input side of the MC.
- The power capacity necessary when separate power is supplied from R1/L11 and S1/L21 is 80 VA.
- If the main circuit power is switched OFF (for 0.1 s or more) then ON again, the inverter is reset and a fault output will not be held.

# 2.6.7 When supplying 24 V external power to the control circuit

Connect the 24 V external power supply across terminals +24 and SD. The 24 V external power supply enables I/O terminal ON/OFF operation, operation panel displays, control functions, and communication during communication operation even during power-OFF of inverter's main circuit power supply. When the main circuit power supply is turned ON, the power supply changes from the 24 V external power supply to the main circuit power supply.

## ◆Specification of the applied 24 V external power supply

| Item | Rate Specification |
|---|---|
| Input voltage | DC23 to 25.5 V |
| Input current | 1.4 A or lower |

Commercially available products (as of October 2013)

| Model | Manufacturer |
|---|---|
| S8JX-N05024C *1<br>Specifications: Capacity 50 W, output voltage 24 VDC, output current 2.1 A<br>Installation method: Front installation with cover<br><br>or<br><br>S8VS-06024 *1<br>Specifications: Capacity 60 W, output voltage 24 VDC, output current 2.5 A<br>Installation method: DIN rail installation<br><br>*1 For the latest information about OMRON power supply, contact OMRON corporation. | OMRON Corporation |

## ◆Starting and stopping the 24 V external power supply operation

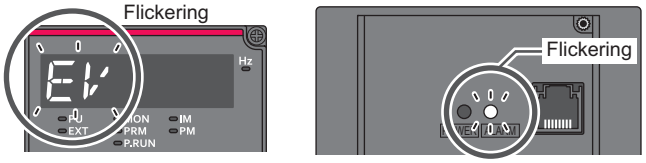
- Supplying 24 V external power while the main circuit power is OFF starts the 24 V external power supply operation. Likewise, turning OFF the main circuit power while supplying 24 V external power starts the 24 V external power supply operation.
- Turning ON the main circuit power stops the 24 V external power supply operation and enables the normal operation.

NOTE

- When the 24 V external power is supplied while the main circuit power supply is OFF, the inverter operation is disabled.
- In the initial setting, when the main power supply is turned ON during the 24 V external power supply operation, a reset is performed in the inverter, then the power supply changes to the main circuit power supply. (The reset can be disabled using **Pr.30**.)

## ◆Confirming the 24 V external power supply input

- During the 24 V external power supply operation, "EV" flickers on the operation panel. The alarm lamp also flickers. Thus, the 24 V external power supply operation can be confirmed even when the operation panel is removed.




- During the 24 V external power supply operation, the 24 V external power supply operation signal (EV) is output. To use the EV signal, set "68 (positive logic) or 168 (negative logic)" in one of **Pr.190 to Pr.196 (output terminal function selection)** to assign function to an output terminal.

## ◆Operation while the 24 V external power is supplied

- Faults history and parameters can be read and parameters can be written (when the parameter write from the operation panel is enabled) using the operation panel keys.
- The safety stop function is disabled during the 24 V external power supply operation.
- During the 24 V external power supply operation, monitored items and signals related to inputs to main circuit power supply, such as output current, converter output voltage, and IPF signal, are invalid.
- The alarms, which have occured when the main circuit power supply is ON, continue to be output after the power supply is changed to the 24 V external power supply. Perform the inverter reset or turn OFF then ON the power to reset the faults.
- The retry function is invalid for all alarms during the 24 V external power supply.
- The output data is retained when "1 or 11" is set in **Pr.495 Remote output selection**.

NOTE

- Inrush current equal to or higher than the 24 V external power supply specification may flow at power-ON. Confirm that the power supply and other devices are not affected by the inrush current and the voltage drop caused by it. Depending on the power supply, the inrush current protection may be activated to disable the power supply. Select the power supply and capacity carefully.
- When the wiring length between the external power supply and the inverter is long, the voltage often drops. Select the appropriate wiring size and length to keep the voltage in the rated input voltage range.
- In a serial connection of several inverters, the current increases when it flows through the inverter wiring near the power supply. The increase of the current causes voltage to drop further. Use the inverter after confirming that the input voltage of each converter unit is within the rated input voltage range. Depending on the power supply, the inrush current protection may be activated to disable the power supply. Select the power supply and capacity carefully.
- "E.SAF" or "E.P24" may appear when the start-up time of the 24 V power supply is too long (less than 1.5 V/s) in the 24 V external power supply operation.
- "E.P24" may appear when the 24 V external power supply input voltage is low. Check the external power supply input.
- Do not touch the control circuit terminal block (circuit board) during the 24 V power supply operation (when conducted). Otherwise you may get an electric shock or burn.

# 2.6.8 Safety stop function

## ◆Function description

The terminals related to the safety stop function are shown below.

| Terminal symbol | Terminal function description | |
|---|---|---|
| S1 *1 | For input of the safety stop channel 1. | Between S1 and SIC, S2 and SIC<br>Open: In safety stop mode<br>Short: Other than the safety stop mode. |
| S2 *1 | For input of the safety stop channel 2. | |
| SIC *1 | Common terminal for terminals S1 and S2. | |
| SO | Outputs when an alarm or failure is detected.<br>The signal is output when no internal safety circuit failure*2 exists. | OFF: Internal safety circuit failure*2<br>ON: No internal safety circuit failure*2 |
| SOC | Open collector output (terminal SO) common | |

*1 In the initial status, terminals S1 and PC, S2 and PC, and SIC and SD are respectively shorted with shorting wires. To use the safety stop function, remove all the shorting wires, and then connect to the safety relay module as shown in the connection diagram.

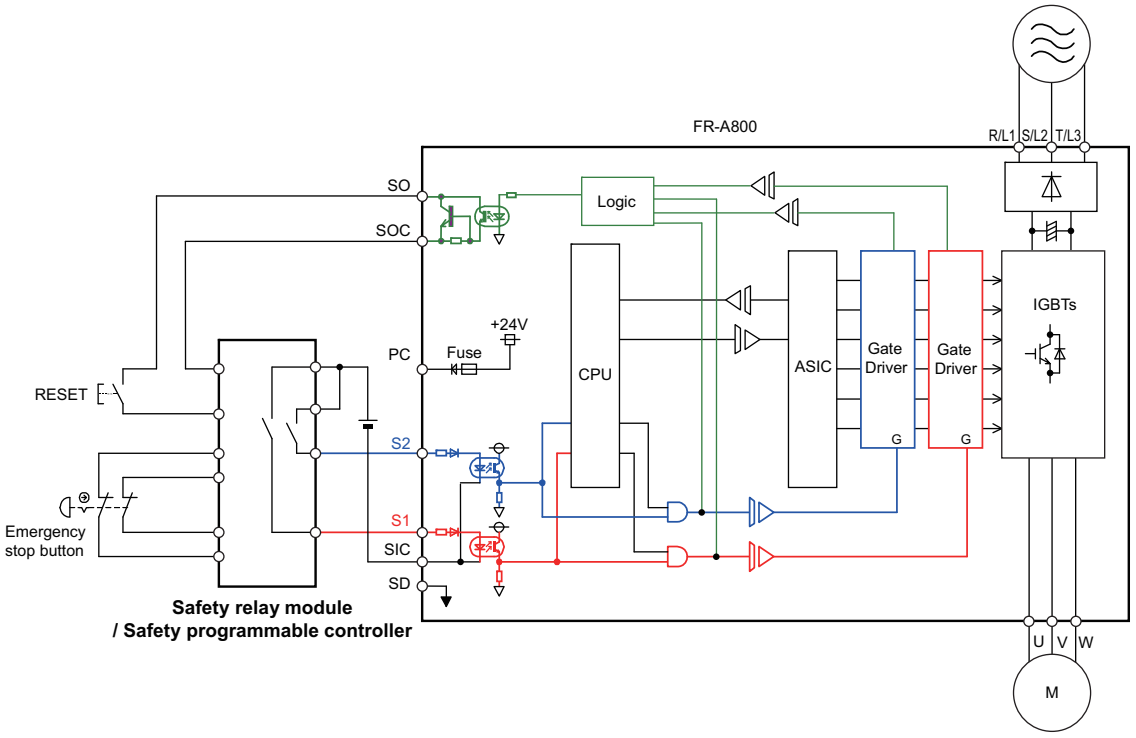
*2 At an internal safety circuit failure, the operation panel displays one of the faults shown on the next page.

NOTE

- Use the terminal SO to output a fault and to prevent restarting of the inverter. The signal cannot be used as safety stop input terminal to other devices.

## ◆Connection diagram

To prevent restart at fault occurrence, connect terminals SO and SOC to the reset button, which are the feedback input terminals of the safety relay module.




## ◆Safety stop function operation

| Input power | Input signal | | Internal safety circuit failure*1 | Output signal | Inverter running status |
|---|---|---|---|---|---|
| | S1-SIC | S2-SIC | | SO *3 | |
| OFF | - | - | - | OFF | Output shutoff (Safe state) |
| ON | Shorted | Shorted | Without | ON | Drive enabled |
| | | | With | OFF | Output shutoff (Safe state) |
| | Open | Open | Without*2 | ON | Output shutoff (Safe state) |
| | | | With | OFF | Output shutoff (Safe state) |
| | Shorted | Open | N/A | OFF | Output shutoff (Safe state) |
| | Open | Shorted | N/A | OFF | Output shutoff (Safe state) |

N/A denotes a condition where circuit fault does not apply.

*1 At an internal safety circuit failure, the operation panel displays one of the fault shown in the following table.

*2 SA is displayed when both of the S1 and S2 signals are in open status and no internal safety circuit failure exists.

*3 ON: Transistor used for an open collector output is conducted.
OFF: Transistor used for an open collector output is not conducted.

## ◆Internal safety circuit failure

At an internal safety circuit failure, the terminal SO turns OFF.

The following faults can cause the internal safety circuit failure (terminal SO-OFF).

| Fault record | Operation panel indication |
|---|---|
| Option fault | E.OPT |
| Communication option fault | E.OP1 |
| Parameter storage device fault | E.PE |
| Retry count excess | E.RET |
| Parameter storage device fault | E.PE2 |
| Operation panel power supply short circuit<br>RS-485 terminals power supply short circuit | E.CTE |
| 24 VDC power fault | E.P24 |
| Safety circuit fault | E.SAF |

| Fault record | Operation panel indication |
|---|---|
| Overspeed occurrence | E.OS |
| Speed deviation excess detection | E.OSD |
| Signal loss detection | E.ECT |
| Excessive position fault | E.OD |
| Brake sequence fault | E.MB1 to E.MB7 |
| Encoder phase fault | E.EP |
| CPU fault | E.CPU |
| | E.5 to E.7 |
| Internal circuit fault | E.13 |

For more details, refer to the Safety Stop Function Instruction Manual (BCN-A23228-001).

Find a PDF copy of this manual in the CD-ROM enclosed with the product.

It is also can be downloaded from the Mitsubishi Electric FA Global Website.

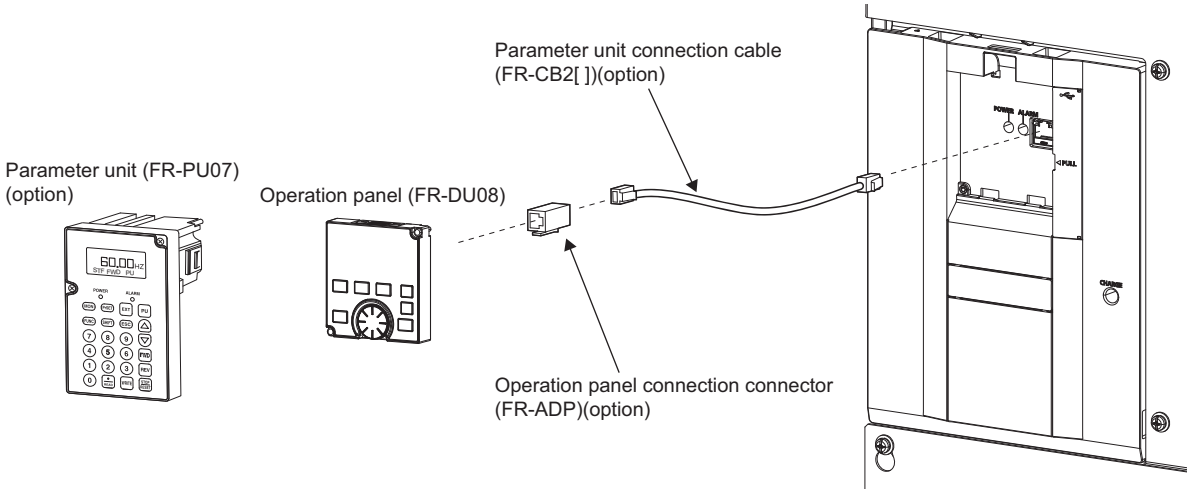
http://www.mitsubishielectric.co.jp/fa/

# 2.7 Communication connectors and terminals

## 2.7.1 PU connector

### ◆Mounting the operation panel (FR-DU08) or parameter unit (FR-PU07) on the enclosure surface

- Having an operation panel (FR-DU08) or a parameter unit (FR-PU07) on the enclosure surface is convenient. With a connection cable, the operation panel (FR-DU08) or the parameter unit (FR-PU07) can be mounted to the enclosure surface and connected to the inverter.
  Use the option FR-CB2[ ], or connectors and cables available on the market.
  (To install the operation panel (FR-DU08), the optional connector (FR-ADP) is required.) )
  Securely insert one end of the connection cable until the stoppers are fixed.




NOTE

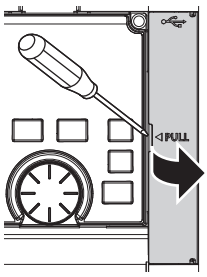
- Refer to the following table when fabricating the cable on the user side. Keep the total cable length within 20 m.
- Commercially available products (as of February 2012)

| Name | Model | Manufacturer |
|---|---|---|
| Communication cable | SGLPEV-T (Cat5e/300 m)<br>24AWG × 4P | Mitsubishi Cable Industries, Ltd. |
| RJ-45 connector | 5-554720-3 | Tyco Electronics |

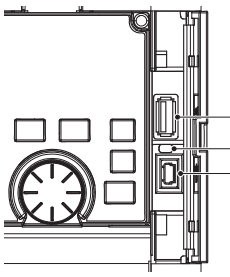
### ◆Communication operation

- Using the PU connector enables communication operation from a personal computer, etc. When the PU connector is connected with a personal, FA or other computer by a communication cable, a user program can run to monitor the inverter or read and write parameters.
  Communication can be performed with the Mitsubishi inverter protocol (computer link operation).
  (For details, refer to the FR-A800 Instruction Manual (Detailed).)

# 2.7.2 USB connector




Place a flathead screwdriver, etc. in a slot and push up the cover to open.



USB host (A connector)

Communication status indicator (LED)

USB device (Mini B connector)

## ◆USB host communication

| Interface | | Conforms to USB1.1 |
|---|---|---|
| Transmission speed | | 12 Mbps |
| Wiring length | | Maximum 5 m |
| Connector | | USB A connector (receptacle) |
| Compatible USB memory | (Format) | FAT32 |
| | Capacity | 1 GB or more (used in the recorder mode of the trace function) |
| | Encryption function | Not available |

- Different inverter data can be saved in a USB memory device.
  The USB host communication enables the following functions.

| Function | Description |
|---|---|
| Parameter copy | • Copies the parameter setting from the inverter to the USB memory device. A maximum of 99 parameter setting files can be saved in a USB memory device.<br>• The parameter setting data copied in the USB memory device can be copied to other inverters. This function is useful in backing up the parameter setting or for sharing the parameter setting among multiple inverters.<br>• The parameter setting data copied in the USB memory device can be saved in a personal computer and edited in FR Configurator 2. |
| Trace | • The monitored data and output status of the signals can be saved in a USB memory device.<br>• The saved data can be imported to FR Configurator2 to diagnose the operating status of the inverter. |
| PLC function data copy | • This function copies the PLC function project data to a USB memory device when the PLC function is used.<br>• The PLC function project data copied in the USB memory device can be copied to other inverters.<br>• This function is useful in backing up the parameter setting and for allowing multiple inverters to operate by the same sequence programs. |

- When the inverter recognizes the USB memory device without any problem, USb.-A is briefly displayed on the operation panel.
- When the USB memory device is removed, USb.-- is briefly displayed on the operation panel.
- The operating status of the USB host can be checked on the LED display of the inverter.

| LED display status | Operating status |
|---|---|
| OFF | No USB connection. |
| ON | The communication is established between the inverter and the USB device. |
| Flickering rapidly | The USB memory device is being accessed. (Do not remove the USB memory device.) |
| Flickering slowly | Error in the USB connection. |

- When a device such as a USB battery charger is connected to the USB connector and an excessive current (500 mA or more) flows, USB host error UF (UF warning) is displayed on the operation panel.
- If a UF warning occurs, disconnect the USB device and set **Pr.1049** = "1" to cancel the USB error. (The UF warning can also be canceled by resetting the inverter power or resetting with the RES signal.)

**NOTE**

- Do not connect devices other than a USB memory device to the inverter.
- If a USB device is connected to the inverter via a USB hub, the inverter cannot recognize the USB memory device properly.
- For the details of usage, refer to the FR-A800 Instruction Manual (Detailed).

## ◆USB device communication

A USB (Ver. 1.1) cable connects the inverter with a personal computer.
Parameter setting and monitoring can be performed by FR Configurator 2.

| | |
|---|---|
| **Interface** | Conforms to USB1.1 |
| **Transmission speed** | 12 Mbps |
| **Wiring length** | Maximum 5 m |
| **Connector** | USB mini B connector (receptacle) |
| **Power supply** | Self-powered |

NOTE

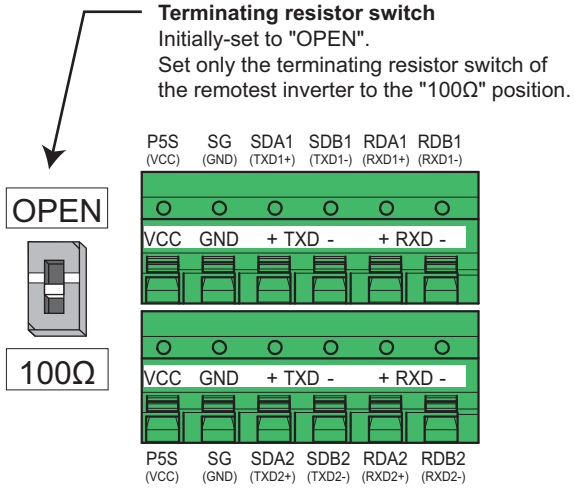
- For the details of FR Configurator2, refer to the Instruction Manual of FR Configurator2.

# 2.7.3 RS-485 terminal block

## ◆Communication operation

| | |
|---|---|
| **Conforming standard** | EIA-485 (RS-485) |
| **Transmission format** | Multidrop link |
| **Communication speed** | 115200 bps maximum |
| **Overall length** | 500 m |
| **Connection cable** | Twisted pair cable (4 pairs) |

The RS-485 terminals enables communication operation from a personal computer, etc. When the PU connector is connected with a personal, FA or other computer by a communication cable, a user program can run to monitor the inverter or read and write parameters.
Communication can be performed with the Mitsubishi inverter protocol (computer link operation) and Modbus-RTU protocol. (For details, refer to the FR-A800 Instruction Manual (Detailed).)



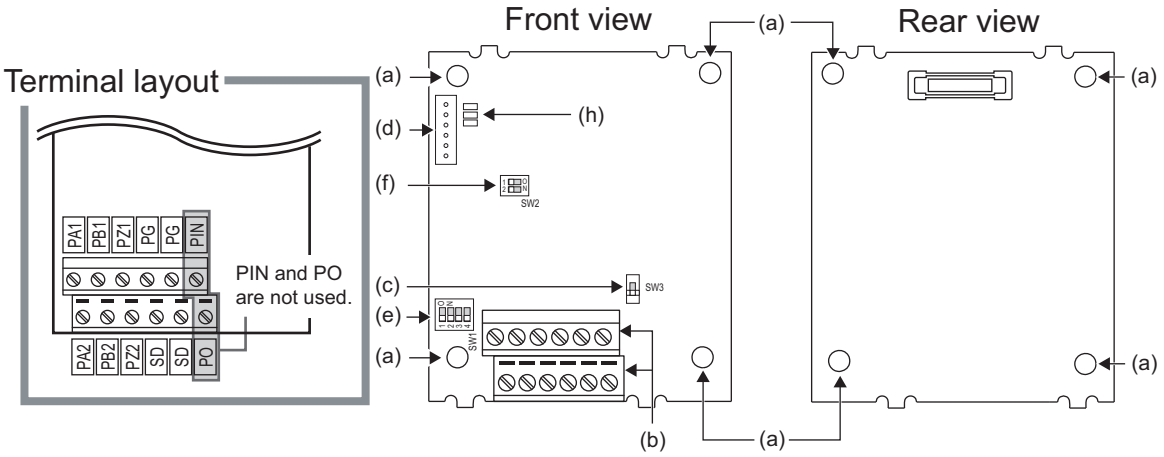

NOTE

- To avoid malfunction, keep the RS-485 terminal wires away from the control circuit board.
- For wiring of the RS-485 terminals used with a plug-in option, lead the wires on the left side of the plug-in option.

# 2.8 Connection of motor with encoder (vector control)

Using an encoder-equipped motor together with the plug-in option FR-A8AP enables speed, torque, and positioning control operations under orientation control, encoder feedback control, and full-scale vector control.

## ◆Appearance and parts name of FR-A8AP




| Symbol | Name | Description | Refer to page |
|---|---|---|---|
| a | Mounting hole | Used for installation to the inverter. | — |
| b | Terminal block | Connected with the encoder. | 53 |
| c | Encoder type selection switch (SW3) | Switches the encoder type (differential line driver/complementary). | 51 |
| d | CON2 connector | Not used. | — |
| e | Terminating resistor selection switch (SW1) | Switches ON or OFF the internal terminating resistor. | 51 |
| f | Switch for manufacturer setting (SW2) | Do not change from the initially-set status. (Switches 1 and 2 are OFF .) | — |
| g | Connector | Connected to the option connector of the inverter. | 9 |
| h | LED for manufacturer check | Not used. | — |

## ◆Terminals of the FR-A8AP

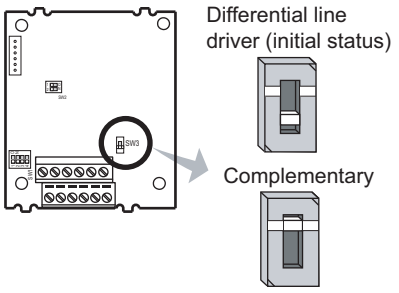
| Terminal symbol | Terminal name | Description |
|---|---|---|
| PA1 | Encoder A-phase signal input terminal | A-, B- and Z-phase signals are input from the encoder. |
| PA2 | Encoder A-phase inverse signal input terminal | |
| PB1 | Encoder B-phase signal input terminal | |
| PB2 | Encoder B-phase inverse signal input terminal | |
| PZ1 | Encoder Z-phase signal input terminal | |
| PZ2 | Encoder Z-phase inverse signal input terminal | |
| PG | Encoder power supply (positive side) input terminal | Input terminal for the encoder power supply. Connect the external power supply (5 V, 12 V, 15 V, 24 V) and the encoder power cable. When the encoder output is the differential line driver type, only 5 V can be input. Make the voltage of the external power supply same as the encoder output voltage. (Check the encoder specification.) |
| SD | Encoder power supply ground terminal | |
| PIN | Not used. | |
| PO | | |

**NOTE**

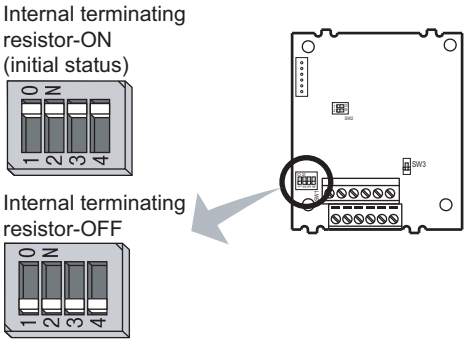
- When the encoder's output voltage differs from its input power supply voltage, the signal loss detection (E.ECT) may occur.
- Incorrect wiring or faulty setting to the encoder will cause a fault such as an overcurrent (E.OC[ ]) and an inverter overload (E.THT).
  Correctly perform the encoder wiring and setting.

## ◆Switches of the FR-A8AP

- Encoder type selection switch (SW3)
  Selects either the differential line driver or complementary setting.
  It is initially set to the differential line driver. Switch its position according to the output circuit.




- Terminating resistor selection switch (SW1)
  Selects ON/OFF of the internal terminating resistor.
  Set the switch to ON (initial status) when an encoder output type is differential line driver, and set to OFF when complementary.
  ON: with internal terminating resistor (initial status)
  OFF: without internal terminating resistor

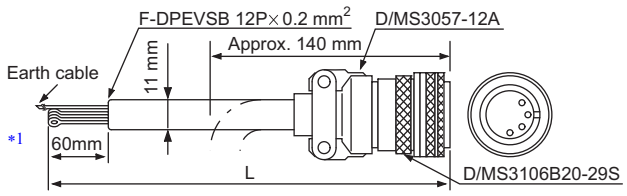



**NOTE**

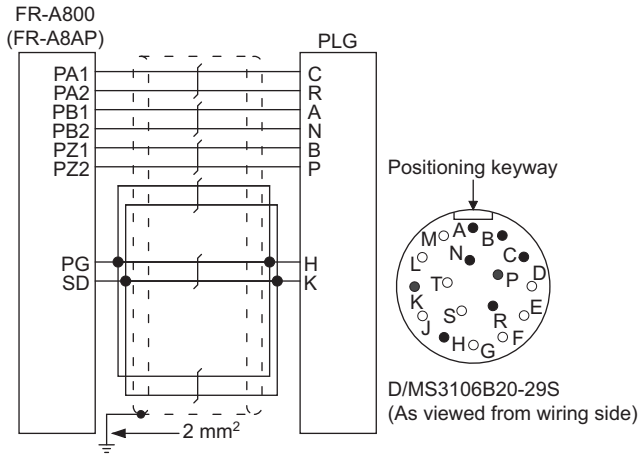
- Set all switches to the same setting (ON/OFF).
- Set the switch "OFF" when sharing an encoder with another unit (NC (computerized numerical controller), etc.) having a terminating resistor under the differential line driver setting.
- Prepare an encoder's power supply (5 V/12 V/15 V/24 V) according to the encoder's output voltage. When the encoder output is the differential line driver type, only 5 V can be input.
- The SW2 switch is for manufacturer setting. Do not change the setting.

## ◆Encoder cable

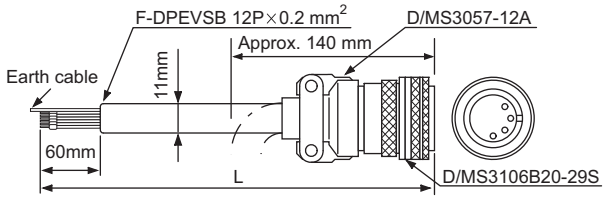
### FR-JCBL




| Model | Length L (m) |
|---|---|
| FR-JCBL5 | 5 |
| FR-JCBL15 | 15 |
| FR-JCBL30 | 30 |

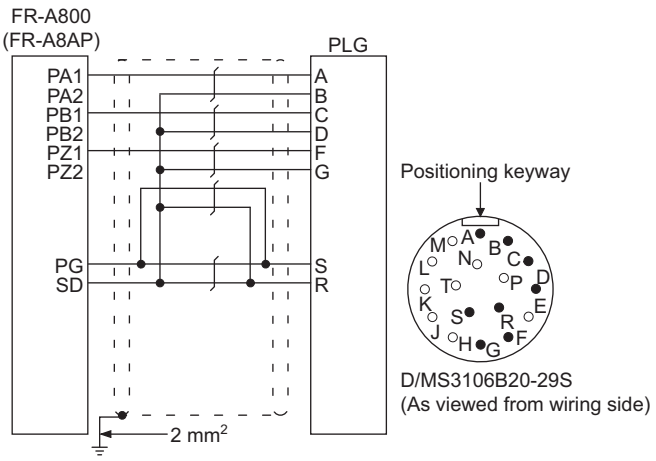



### FR-V7CBL




- Shield earthing P-clip is included.

| Model | Length L (m) |
|---|---|
| FR-V7CBL5 | 5 |
| FR-V7CBL15 | 15 |
| FR-V7CBL30 | 30 |




*1 As the terminal block of the FR-A8AP is an insertion type, cables need to be treated. (Refer to the following description.)

- As the terminal block of the FR-A8AP is an insertion type, cables need to be treated when the encoder cables of the inverter are crimping terminals. Cut the crimping terminal of the encoder cable and strip its sheath to make its cable wires loose.
  Also, treat the shielding wires of the shielded twisted pair cable to ensure that they will not contact conductive areas. Wire the stripped cable after twisting it to prevent it from becoming loose. In addition, do not solder it.

**NOTE**

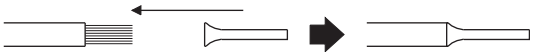
- Information on blade terminals
  Commercially available products (as of February 2012)
  Phoenix Contact Co., Ltd.

| Terminal screw size | Cable gauge (mm²) | Blade terminal model | | Crimping tool name |
|---|---|---|---|---|
| | | (With insulation sleeve) | (Without insulation sleeve) | |
| M2 | 0.3, 0.5 | AI 0,5-6WH | A 0,5-6 | CRIMPFOX 6 |

NICHIFU Co.,Ltd.

| Terminal screw size | Cable gauge (mm²) | Blade terminal product number | Insulation product number | Crimping tool product number |
|---|---|---|---|---|
| M2 | 0.3 to 0.75 | BT 0.75-7 | VC 0.75 | NH 69 |

- When using a blade terminal (without insulation sleeve), take caution that the twisted wires do not come out.



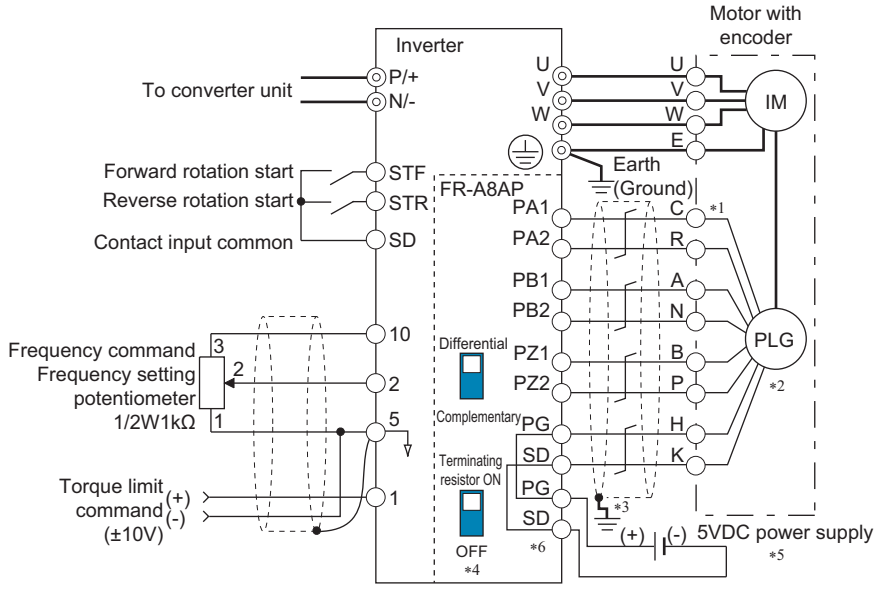
• Connection terminal compatibility table

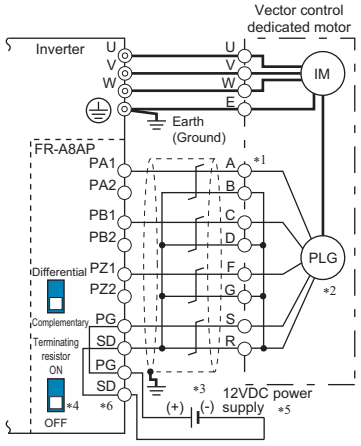
| Encoder cable | | FR-V7CBL | FR-JCBL |
|---|---|---|---|
| FR-A8AP terminal | PA1 | PA | PA |
| | PA2 | Do not connect anything to this. | PAR |
| | PB1 | PB | PB |
| | PB2 | Do not connect anything to this. | PBR |
| | PZ1 | PZ | PZ |
| | PZ2 | Do not connect anything to this. | PZR |
| | PG | PG | 5E |
| | SD | SD | AG2 |

## ◆Wiring example

• Speed control

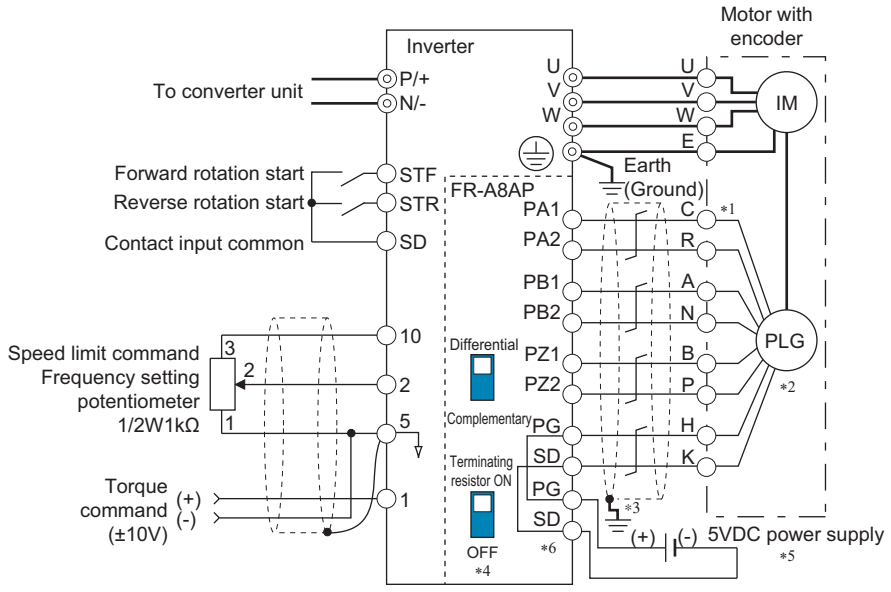
| Standard motor with encoder, 5 V differential line driver | Vector control dedicated motor, 12 V complementary |
|---|---|

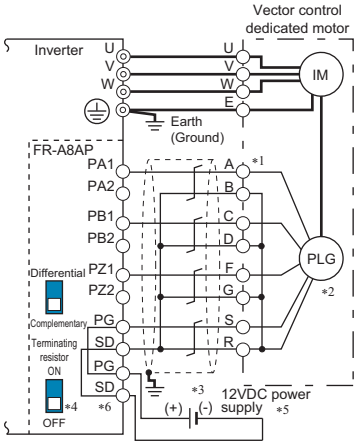



• Torque control

| Standard motor with encoder (SF-JR), 5 V differential line driver | Vector control dedicated motor, 12 V complementary |
|---|---|

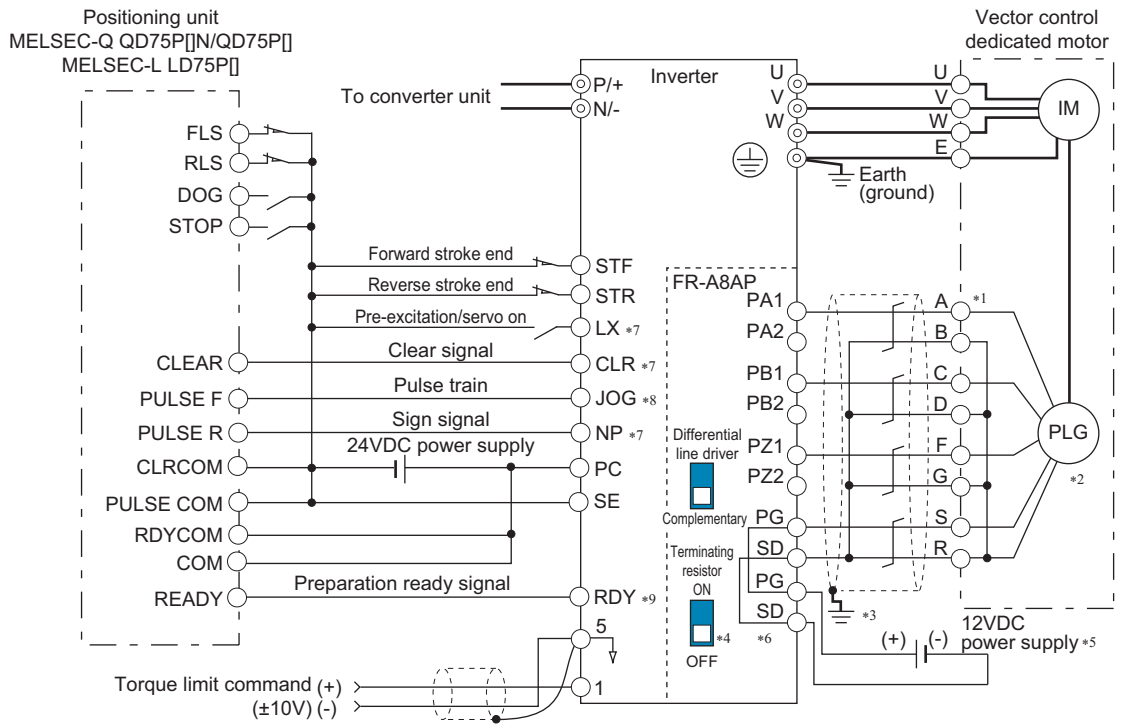


## Connection of motor with encoder (vector control)

• Position control

**Vector control dedicated motor, 12 V complementary**




*1 The pin number differs according to the encoder used.
Speed, control, torque control, and position control by pulse train input are available with or without the Z-phase being connected.

*2 Connect the encoder so that there is no looseness between the motor and motor shaft. Speed ratio must be 1:1.

*3 Earth (ground) the shield of the encoder cable to the enclosure using a tool such as a P-clip. (Refer to **page 55**.)

*4 For the complementary, set the terminating resistor selection switch to OFF position. (Refer to **page 51**.)

*5 A separate power supply of 5 V / 12 V / 15 V / 24 V is necessary according to the encoder power specification.
When the encoder output is the differential line driver type, only 5 V can be input.
Make the voltage of the external power supply the same as the encoder output voltage, and connect the external power supply between PG and SD.

*6 For terminal compatibility of the FR-JCBL, FR-V7CBL, and FR-A8AP, refer to **page 53**.

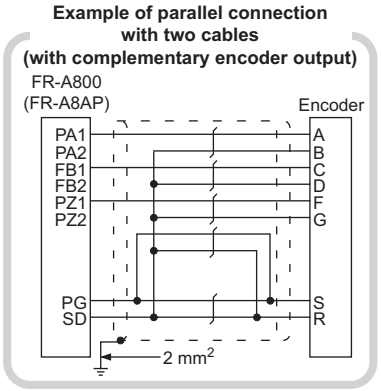
*7 Assign the function using **Pr.178 to Pr.184, Pr.187 to Pr.189 (input terminal function selection)**.

*8 When position control is selected, terminal JOG function is invalid and simple position pulse train input terminal becomes valid.

*9 Assign the function using **Pr.190 to Pr.194 (output terminal function selection)**.

## ◆Instructions for encoder cable wiring

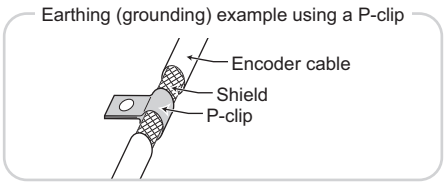
- Use shielded twisted pair cables (0.2 $mm^2$ or larger) to connect the FR-A8AP. For the wiring to the terminals PG and SD, use several cables in parallel or use a thick cable, according to the wiring length.
  To protect the cables from noise, run them away from any source of noise (such as the main circuit and power supply voltage).



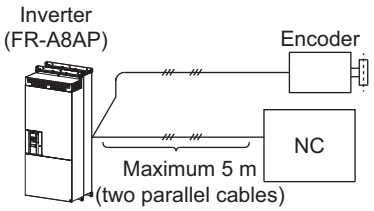

| Wiring length | Parallel connection | | Larger-size cable |
|---|---|---|---|
| Within 10 m | At least two cables in parallel | Cable gauge 0.2 $mm^2$ | 0.4 $mm^2$ or larger |
| Within 20 m | At least four cables in parallel | | 0.75 $mm^2$ or larger |
| Within 100 m*1 | At least six cables in parallel | | 1.25 $mm^2$ or larger |

*1 When differential line driver is set and a wiring length is 30 m or more.
The wiring length can be extended to 100 m by increasing the 5 V power supply (approximately to 5.5 V) while using six or more 0.2 $mm^2$ gauge cables in parallel or a 1.25 $mm^2$ or larger gauge cable. The voltage applied must be within power supply specifications of encoder.

- To reduce noise of the encoder cable, earth (ground) the encoder's shielded cable to the enclosure (as close as possible to the inverter) with a P-clip or U-clip made of metal.




- When one encoder is shared between FR-A8AP and CNC (computerized numerical controller), its output signal should be connected as shown below. In this case, the wiring length between FR-A8AP and CNC should be as short as possible, within 5 m.




**NOTE**

- For the details of the optional encoder dedicated cable (FR-JCBL/FR-V7CBL), refer to page 52.
- The FR-V7CBL is provided with a P-clip for earthing (grounding) shielded cables.

## ◆Parameter for the encoder (Pr.359, Pr.369)

<table>
<tr><th>Pr.</th><th>Name</th><th>Initial value</th><th>Setting range</th><th colspan="2">Description</th></tr>
<tr><td rowspan="4">359<br>C141</td><td rowspan="4">Encoder rotation direction</td><td rowspan="4">1</td><td>0</td><td rowspan="2">Set when using a motor for which forward rotation (encoder) is clockwise (CW) viewed from the shaft.<br> <br></td><td>Set for the operation at 120 Hz or less.</td></tr>
<tr><td>100</td><td>Set for the operation at a frequency higher than 120 Hz.</td></tr>
<tr><td>1</td><td rowspan="2">Set when using a motor for which forward rotation (encoder) is counterclockwise (CCW) viewed from the shaft.<br> <br></td><td>Set for the operation at 120 Hz or less.</td></tr>
<tr><td>101</td><td>Set for the operation at a frequency higher than 120 Hz.</td></tr>
<tr><td>369<br>C140</td><td>Number of encoder pulses</td><td>1024</td><td>0 to 4096</td><td colspan="2">Set the number of encoder pulses output.<br>Set the number of pulses before it is multiplied by 4.</td></tr>
</table>

The above parameters can be set when the FR-A8AP (option) is mounted.

## ◆Parameter settings for the motor under vector control

| Motor name | Pr.9 Electronic thermal O/L relay | Pr.71 Applied motor | Pr.80 Motor capacity | Pr.81 Number of motor poles | Pr.359 Encoder rotation direction | Pr.369 Number of encoder pulses |
|---|---|---|---|---|---|---|
| Standard motor | Rated motor current | 0 (3) *1 | Motor capacity | Number of motor poles | *2 | *2 |
| Constant-torque motor | Rated motor current | 1 (13) *1 | Motor capacity | Number of motor poles | *2 | *2 |

*1 Offline auto tuning is required (Refer to the FR-A800 Instruction Manual (Detailed))

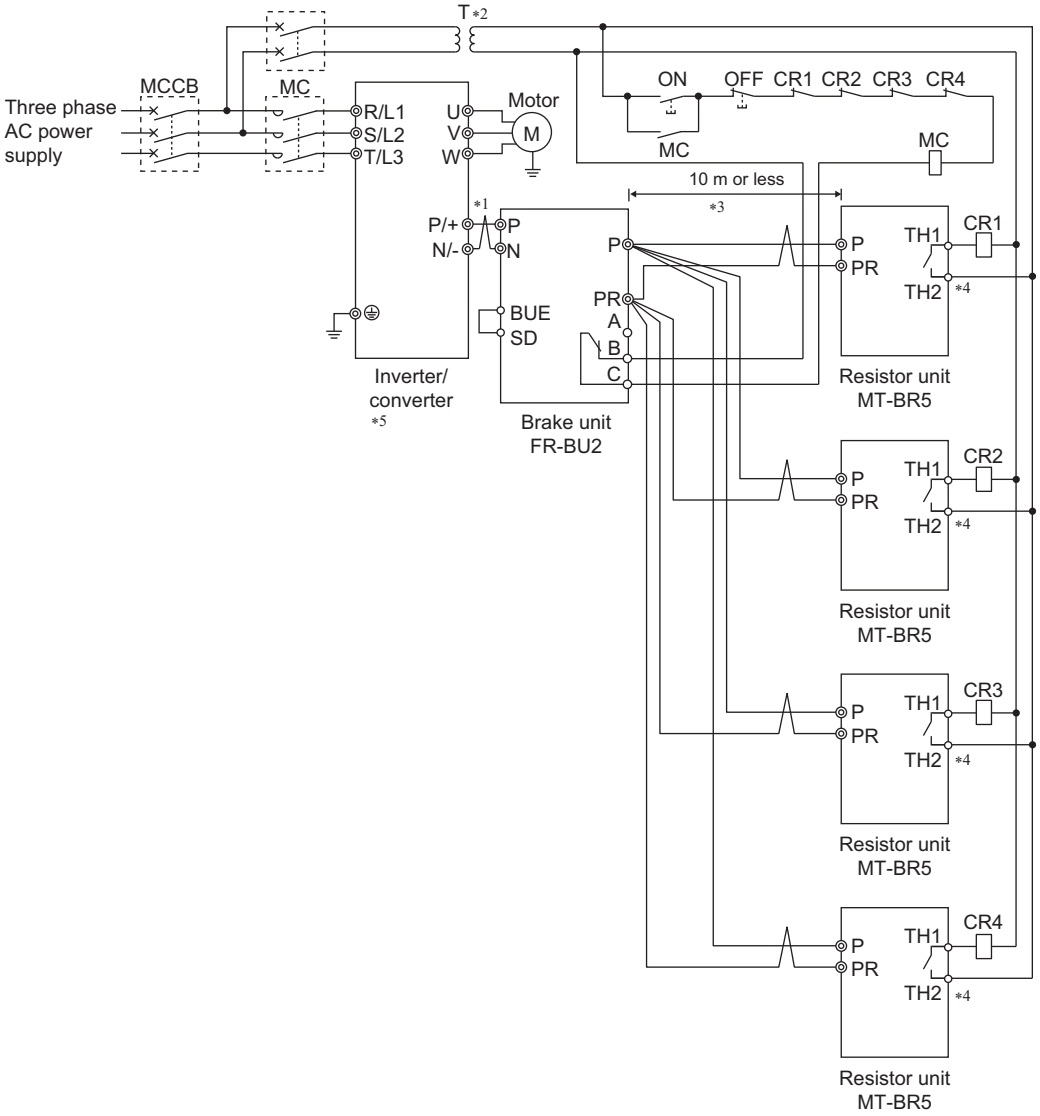
*2 Set this parameter according to the motor.

# 2.9 Connection of stand-alone option units

The inverter accepts a variety of stand-alone option units as required.
Incorrect connection will cause inverter damage or accident. Connect and operate the option unit carefully in accordance with the corresponding option unit manual.

## 2.9.1 Connection of the brake unit (FR-BU2)

Connect the brake unit (FR-BU2) as shown below to improve the braking capability during deceleration.
After wiring securely, set **Pr.30 Regenerative function selection** = "11" .
Set **Pr.0 Brake mode selection** = "2" in the brake unit FR-BU2.




*1 When wiring, make sure to match the terminal symbol (P/+, N/-) at the inverter side and at the brake unit (FR-BU2) side. (Incorrect connection will damage the inverter and brake unit.)
*2 When the power supply is 400 V class, install a stepdown transformer.
*3 The wiring distance between the inverter, brake unit (FR-BU2) and resistor unit (MT-BR5) must be within 5 m each. Even when the cable is twisted, the wiring length must be within 10 m.
*4 The contact between TH1 and TH2 is open in the normal status and is closed at a fault.
*5 The CN8 connector used with the MT-BU5 type brake unit is not used.

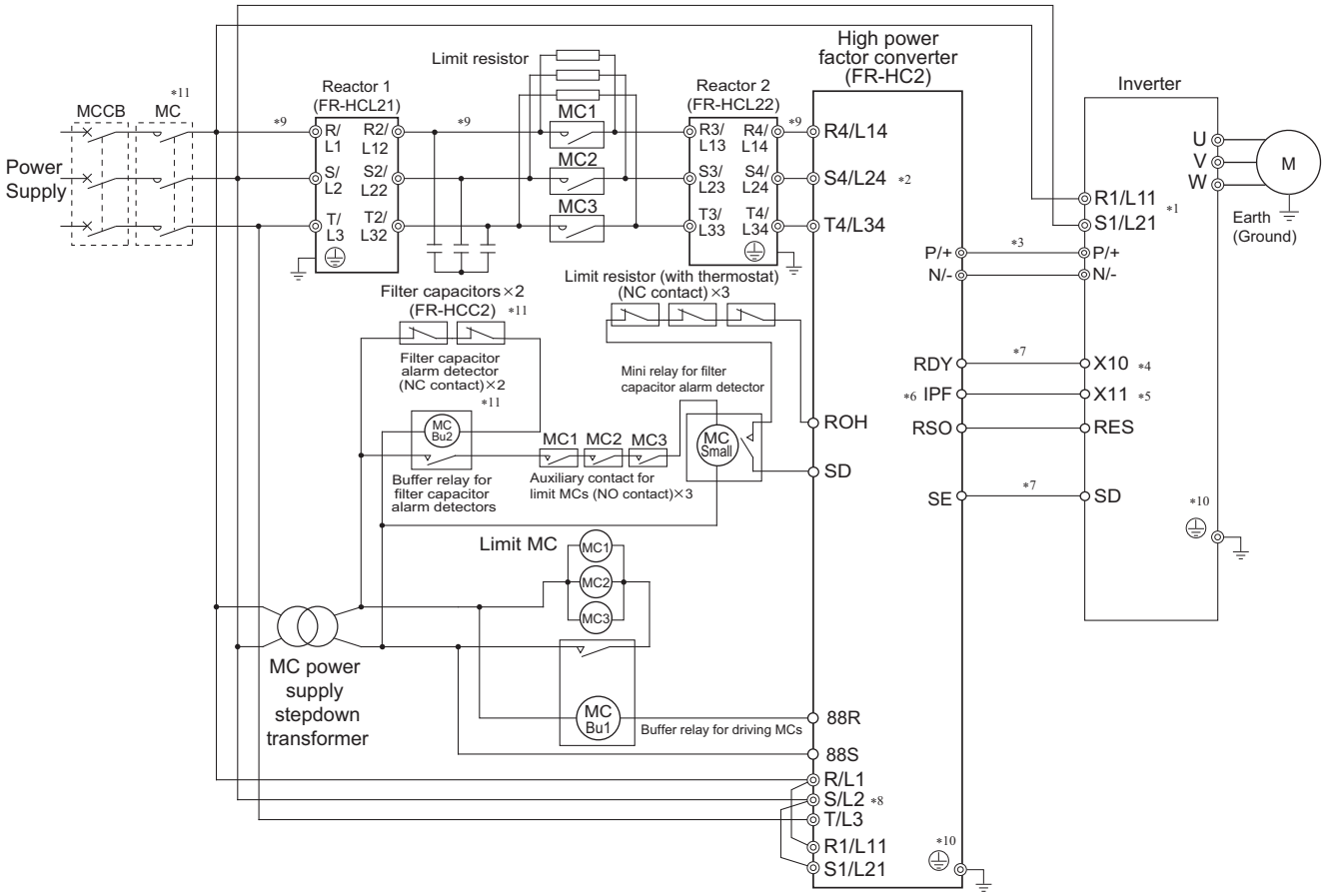
NOTE

- The stall prevention (overvoltage), oL, does not occur while **Pr.30 Regenerative function selection** = "11" .
- For the parameter details, refer to the FR-A800 Instruction Manual (Detailed).

# 2.9.2 Connection of the high power factor converter (FR-HC2)

When connecting the high power factor converter (FR-HC2) to suppress power harmonics, perform wiring securely as shown below. Incorrect connection will damage the high power factor converter and the inverter.

After making sure that the wiring is correct, set "rated motor voltage" in **Pr.19 Rated motor voltage** (under V/F control) or **Pr.83 Regenerative function selection** (under other that V/F control) and "2" in **Pr.30 Regenerative function selection**.




*1 Remove jumpers installed in terminals R1/L11 and S1/L21 of the inverter, and connect the power supply for the control circuit to terminals R1/L11 and S1/L21.

*2 The voltage phases of terminals R4/L14, S4/L24, and T4/L34 and the voltage phases of terminals R/L1, S/L2, and T/L3 must be matched.

*3 Do not install an MCCB across the terminals P/+ and N/- (across terminals P and P/+ or across N and N/-). Connecting the opposite polarity of terminals N/- and P/+ will damage the inverter.
For the A802 series, installation of a fuse is not required.

*4 Change the FR-HC2 parameter setting to **Pr.10 RDY signal logic selection** = "0" (positive logic).

*5 Use **Pr.178 to Pr.189 (input terminal function selection)** to assign the terminals used for the X10 signal.
For RS-485 or any other communication where the start command is only transmitted once, use the X11 signal to save the operation mode at the time of an instantaneous power failure.

*6 Assign the IPF signal to an FR-HC2 terminal. (Refer to the Instruction Manual of FR-HC2.)

*7 Always connect the FR-HC2 terminal RDY to the inverter terminal MRS(X10), and the FR-HC2 terminal SE to the inverter terminal SD. Not connecting these terminals may damage the FR-HC2.

*8 Always connect the R/L1, S/L2, and T/L3 terminals of FR-HC2 to the power supply. Operating the inverter without connecting them will damage the FR-HC2.

*9 Do not install an MCCB or MC between the reactor 1 terminals (R/L1, S/L2, T/L3) and the FR-HC2 terminals (R4/L14, S4/L24, T4/L34). It will not operate properly.

*10 Securely perform grounding (earthing) by using the grounding (earthing) terminal.

*11 The number of connected peripheral devices differs according to the capacity. For the detail, refer to the FR-HC2 Instruction Manual.

**NOTE**

- The voltage phases of terminals R/L1, S/L2, and T/L3 and the voltage phases of terminals R4/L14, S4/L24, and T4/L34 must be matched.
- The control logic (sink logic/source logic) of the high power factor converter and the inverter must be matched. (Refer to page 38.)
- When using a sine wave filter with FR-HC2, select MT-BSL-HC as a reactor for the sine wave filter.
- For the parameter details, refer to the FR-A800 Instruction Manual (Detailed).

# 3 PRECAUTIONS FOR USE OF THE INVERTER

This chapter explains the precautions for use of this product.
Always read the instructions before using the equipment.


3.1 Electro-magnetic interference (EMI) and leakage currents ..60
3.2 Power supply harmonics .....67
3.3 Installation of a reactor .....70
3.4 Power-OFF and magnetic contactor (MC) .....71
3.5 Countermeasures against deterioration of the 400 V class motor insulation.....72
3.6 Checklist before starting operation .....73
3.7 Failsafe system which uses the inverter .....76

# 3.1 Electro-magnetic interference (EMI) and leakage currents

## 3.1.1 Leakage currents and countermeasures

Capacitances exist between the inverter I/O cables, other cables and earth and in the motor, through which a leakage current flows. Since its value depends on the static capacitances, carrier frequency, etc., low acoustic noise operation at the increased carrier frequency of the inverter will increase the leakage current. Therefore, take the following countermeasures. Select the earth leakage current breaker according to its rated sensitivity current, independently of the carrier frequency setting.

### ◆To-earth (ground) leakage currents

Leakage currents may flow not only into the inverter's own line but also into the other lines through the earthing (grounding) cable, etc. These leakage currents may operate earth leakage circuit breakers and earth leakage relays unnecessarily.

●Countermeasures

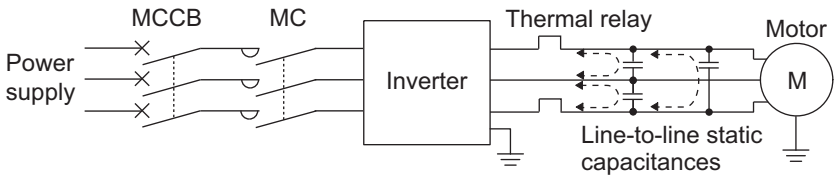
- If the carrier frequency setting is high, decrease the **Pr.72 PWM frequency selection** setting.
  Note that motor noise increases. Selecting **Pr.240 Soft-PWM operation selection** makes the sound inoffensive.
- By using earth leakage circuit breakers designed for harmonic and surge suppression in the inverter's own line and other line, operation can be performed with the carrier frequency kept high (with low noise).

●To-earth (ground) leakage currents

- Take caution as long wiring will increase the leakage current. Decreasing the carrier frequency of the inverter reduces the leakage current.
- Increasing the motor capacity increases the leakage current.

### ◆Line-to-line leakage currents

Harmonics of leakage currents flowing in static capacitances between the inverter output cables may operate the external thermal relay unnecessarily.




**Line-to-line leakage currents path**

●Countermeasures

- Use **Pr.9 Electronic thermal O/L relay**.
- If the carrier frequency setting is high, decrease the **Pr.72 PWM frequency selection** setting.
  Note that motor noise increases. Selecting **Pr.240 Soft-PWM operation selection** makes the sound inoffensive.
  To ensure that the motor is protected against line-to-line leakage currents, it is recommended to use a temperature sensor to directly detect motor temperature.

●Installation and selection of the molded case circuit breaker

Install a molded case circuit breaker (MCCB) on the power receiving side to protect the wiring at the inverter input side. Select an MCCB according to the inverter input side power factor, which depends on the power supply voltage, output frequency and load. Especially for a completely electromagnetic MCCB, a slightly large capacity must be selected since its operation characteristic varies with harmonic currents. (Check it in the data of the corresponding breaker.) As an earth leakage current breaker, use the Mitsubishi earth leakage current breaker designed for harmonics and surge suppression.

## ◆Selecting the rated sensitivity current for the earth leakage circuit breaker

When using an earth leakage circuit breaker with the inverter circuit, select its rated sensitivity current as follows, independently of the PWM carrier frequency.

- Breaker designed for harmonic and surge suppression
  Rated sensitivity current
  $I\Delta n \geq 10 \times (Ig1 + Ign + Igi + Ig2 + Igm)$
- Standard breaker
  Rated sensitivity current
  $I\Delta n \geq 10 \times \{Ig1 + Ign + Igi + 3 \times (Ig2 + Igm)\}$

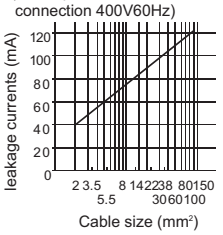
Ig1, Ig2: Leakage currents in wire path during commercial power supply operation

Ign: Leakage current of inverter input side noise filter

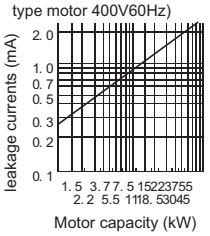
Igm: Leakage current of motor during commercial power supply operation

Igi: Leakage current of inverter unit
(When the converter unit is connected, add the leakage current of converter unit.)

Example of leakage current per 1km during the commercial power supply operation when the CV cable is routed in metal conduit
(Three-phase three-wire delta connection 400V60Hz)

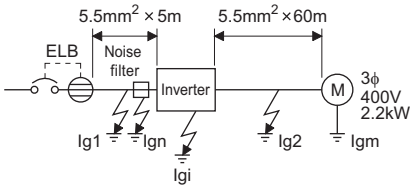



Leakage current example of three-phase induction motor during the commercial power supply operation
(Totally-enclosed fan-cooled type motor 400V60Hz)




For "人" connection, the amount of leakage current is appox.1/3 of the above value.

<Example>




- Selection example for the 人 connection of the 400 V class

| Item | Breaker designed for harmonic and surge suppression | Standard breaker |
|---|---|---|
| Leakage current Ig1 (mA) | $\frac{1}{3} \times 66 \times \frac{5\text{ m}}{1000\text{ m}} = 0.11$ | |
| Leakage current Ign (mA) | 0 (without noise filter) | |
| Leakage current Igi (mA) | 1 (without EMC filter)<br>For the leakage current of the inverter, refer to the following table. | |
| Leakage current Ig2 (mA) | $\frac{1}{3} \times 66 \times \frac{60\text{ m}}{1000\text{ m}} = 1.32$ | |
| Motor leakage current Igm (mA) | 0.36 | |
| Total leakage current (mA) | 2.79 | 6.15 |
| Rated sensitivity current (mA) (≥ Ig × 10) | 30 | 100 |

- Inverter/converter unit leakage current
  400 V class (input power condition: 440 V/60 Hz, power supply unbalance within 3%)

| Inverter/ converter unit | FR-A800 (Standard model) | | FR-A802 (Separated converter type) | Converter unit FR-CC2 | | | |
|---|---|---|---|---|---|---|---|
| | | | | H315K, H355K | | H400K to H500K | |
| EMC filter | ON | OFF | - | ON | OFF | ON | OFF |
| Phase earthing (grounding) | 35 | 2 | 2 | 35 | 2 | 70 | 2 |
| Earthed-neutral system | 2 | 1 | 1 | 2 | 1 | 2 | 1 |

(mA)

NOTE

- Install the earth leakage circuit breaker (ELB) on the input side of the converter unit.
- In the 人 connection earthed-neutral system, the sensitivity current is blunt against a ground fault in the inverter output side. Earthing (Grounding) must conform to the requirements of national and local safety regulations and electrical codes. (NEC section 250, IEC 536 class 1 and other applicable standards)
- When the breaker is installed on the output side of the inverter, it may be unnecessarily operated by harmonics even if the effective value is within the rating.
  In this case, do not install the breaker since the eddy current and hysteresis loss will increase, leading to temperature rise.
- The following models are standard breakers BV-C1, BC-V, NVB, NV-L, NV-G2N, NV-G3NA, NV-2F, earth leakage relay (except NV-ZHA), and NV with AA neutral wire open-phase protection.
  The other models are designed for harmonic and surge suppression: NV-C/NV-S/MN series, NV30-FA, NV50-FA, BV-C2, earth leakage alarm breaker (NF-Z), NV-ZHA, and NV-H.
- For the leakage current of a 75 kW or higher motor, contact the motor manufacturer.

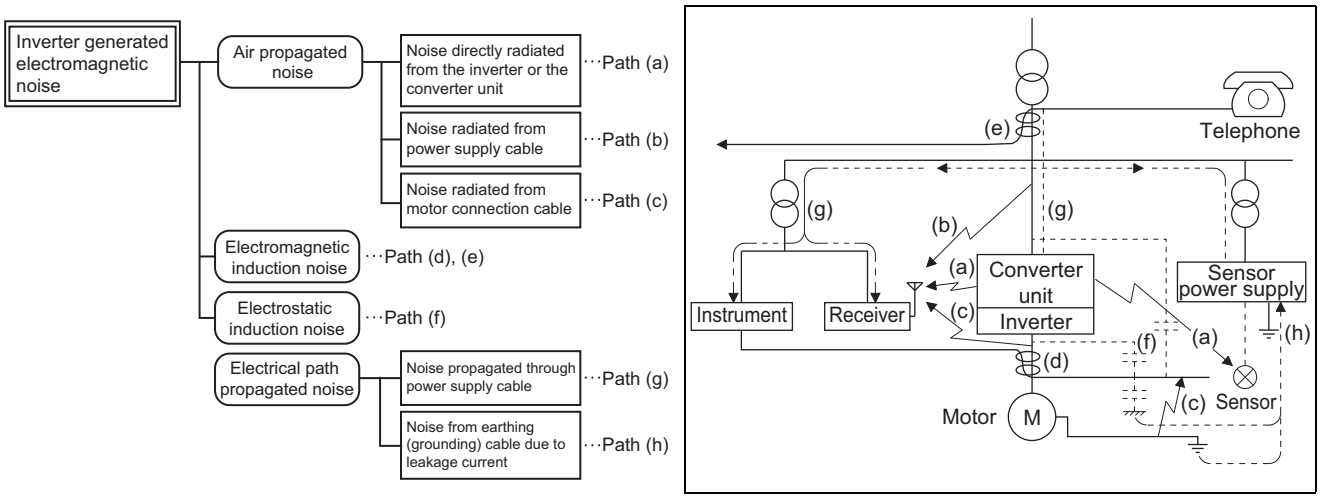
# 3.1.2 Countermeasures against inverter-generated EMI

Some electromagnetic noises enter the inverter or the converter unit to cause its malfunction, and others are radiated by the inverter or the converter unit to cause the peripheral devices to malfunction. Though the inverter or the converter unit is designed to have high immunity performance, it handles low-level signals, so it requires the following basic techniques. Also, since the inverter chops outputs at high carrier frequency, that could generate electromagnetic noises. If these electromagnetic noises cause peripheral devices to malfunction, EMI countermeasures should be taken to suppress noises. These techniques differ slightly depending on EMI paths.

- Basic techniques
  - Do not run the power cables (I/O cables) and signal cables of the inverter or the converter unit in parallel with each other and do not bundle them.
  - Use shielded twisted pair cables for the detector connecting and control signal cables and connect the sheathes of the shielded cables to terminal SD.
  - Ground (Earth) the inverter or the converter unit, motor, etc. at one point.

- Techniques to reduce electromagnetic noises that enter and cause a malfunction of the inverter or the converter unit (EMI countermeasures)
  When devices that generate many electromagnetic noises (which use magnetic contactors, electromagnetic brakes, many relays, for example) are installed near the inverter or the converter unit and it may malfunction due to electromagnetic noises, the following countermeasures must be taken:
  - Provide surge suppressors for devices that generate many electromagnetic noises to suppress electromagnetic noises.
  - Install data line filters (**page 64**) to signal cables.
  - Ground (Earth) the shields of the detector connection and control signal cables with cable clamp metal.

- Techniques to reduce electromagnetic noises that are radiated by the inverter to or converter unit cause the peripheral devices to malfunction (EMI countermeasures)
  Noises generated from the inverter or the converter unit are largely classified into those radiated by the cables connected to the inverter or the converter unit and its main circuits (I/O), those electromagnetically and electrostatically induced to the signal cables of the peripheral devices close to the main circuit power supply, and those transmitted through the power supply cables.



| Noise propagation path | Countermeasure |
|---|---|
| (a)(b)(c) | When devices that handle low-level signals and are liable to malfunction due to electromagnetic noises, e.g. instruments, receivers and sensors, are contained in the enclosure that contains the inverter or the converter unit, or when their signal cables are run near the inverter, the devices may malfunction due to by air-propagated electromagnetic noises. The following countermeasures must be taken:<br>• Install easily affected devices as far away as possible from the inverter or the converter unit.<br>• Run easily affected signal cables as far away as possible from the inverter or the converter unit, and its I/O cables.<br>• Do not run the signal cables and power cables (inverter or converter unit I/O cables) in parallel with each other and do not bundle them.<br>• Set the EMC filter ON/OFF connector of the converter unit to the ON position. (Refer to **page 66**.)<br>• Inserting a line noise filter into the output suppresses the radiated noise from the cables.<br>• Use shielded cables as signal cables and power cables and run them in individual metal conduits to produce further effects. |
| (d)(e)(f) | When the signal cables are run in parallel with or bundled with the power cables, magnetic and static induction noises may be propagated to the signal cables to cause malfunction of the devices and the following countermeasures must be taken:<br>• Install easily affected devices as far away as possible from the inverter or the converter unit.<br>• Run easily affected signal cables as far away as possible from the inverter or the converter unit, and its I/O cables.<br>• Do not run the signal cables and power cables (inverter or converter unit I/O cables) in parallel with each other and do not bundle them.<br>• Use shielded cables as signal cables and power cables and run them in individual metal conduits to produce further effects. |
| (g) | When the power supplies of the peripheral devices are connected to the power supply of the inverter or the converter unit in the same line, its generated noises may flow back through the power supply cables to cause malfunction of the devices and the following countermeasures must be taken:<br>• Set the EMC filter ON/OFF connector of the converter unit to the ON position. (Refer to **page 66**.)<br>• Install the line noise filter to the power cables (output cables) of the inverter. |
| (h) | When a closed loop circuit is formed by connecting the peripheral device wiring to the inverter or the converter unit, leakage currents may flow through the earthing (grounding) cable of the inverter or the converter unit to cause the device to malfunction. In that case, disconnecting the earthing (grounding) cable from the device may stop the malfunction of the device. |

### ●Data line filter

Data line filter is effective as an EMI countermeasure. Provide a data line filter for the detector cable, etc.

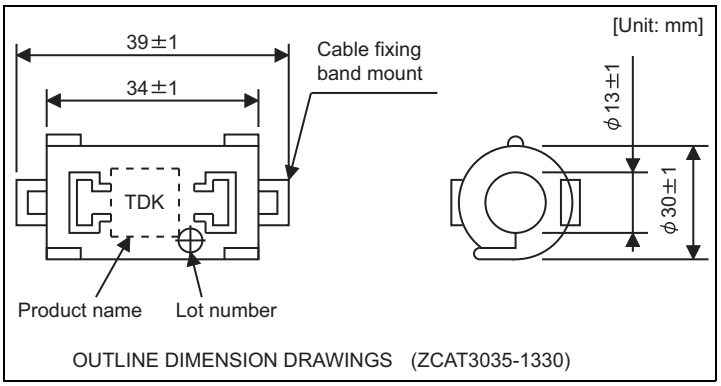
<Example> Data line filter: ZCAT3035-1330 (by TDK)

ESD-SR-250 (by NEC TOKIN)

Impedance (ZCAT3035-1330)

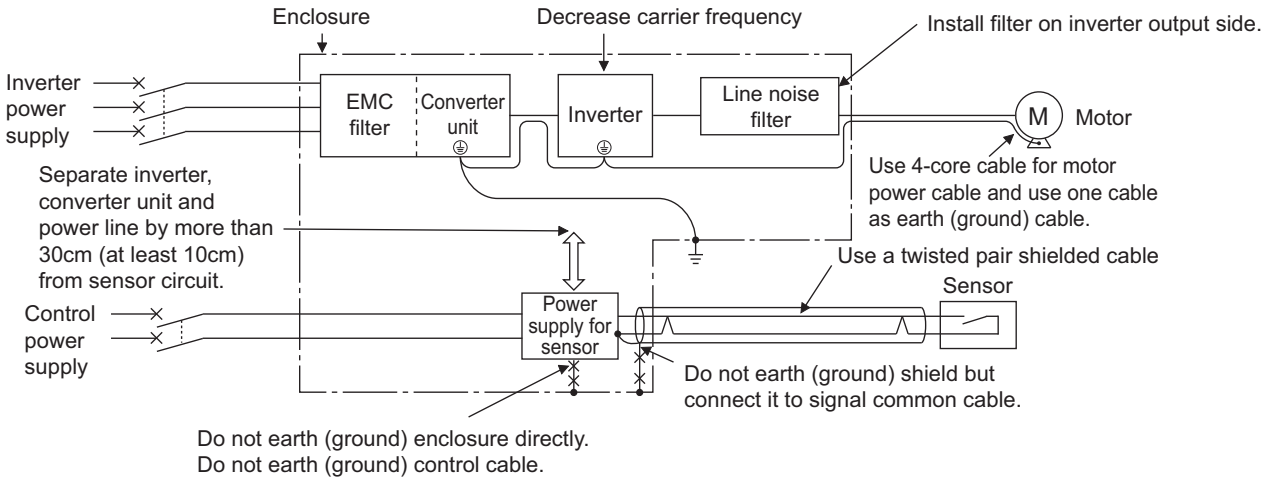
| Impedance (Ω) | |
|---|---|
| 10 to 100 MHz | 100 to 500 MHz |
| 80 | 150 |

The impedance values above are reference values, and not guaranteed values.




OUTLINE DIMENSION DRAWINGS (ZCAT3035-1330)

## ●EMI countermeasure example

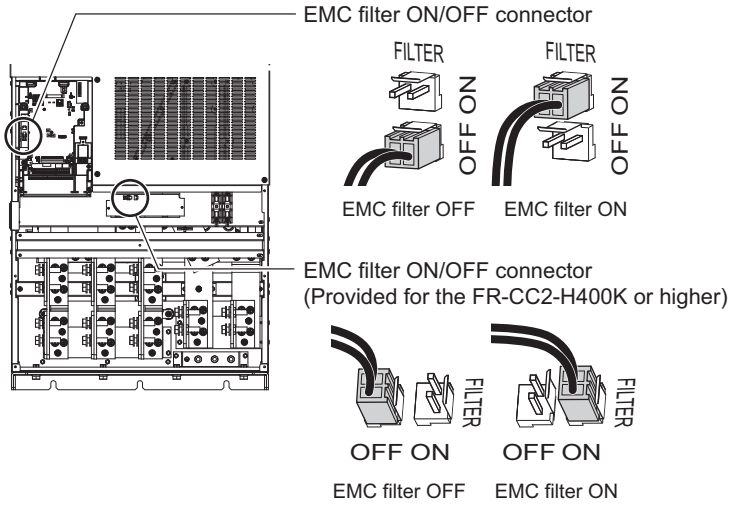



**NOTE**

- For compliance with the EU EMC Directive, refer to page 109.

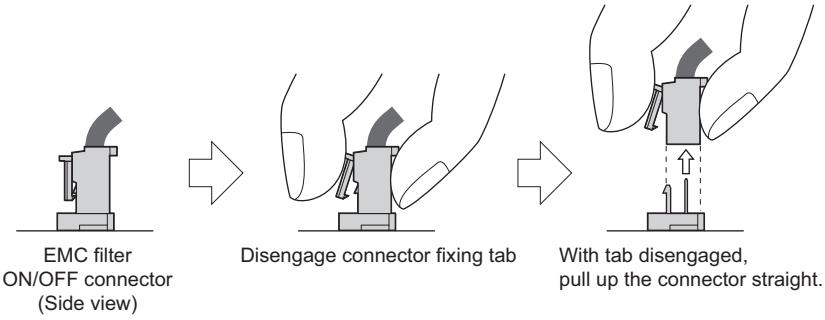
# 3.1.3 Converter unit (FR-CC2) built-in EMC filter

The converter unit (FR-CC2) is equipped with a built-in EMC filter (capacitive filter).
These filters are effective in reducing air-propagated noise on the input side of the converter unit.
To enable the EMC filter, fit the EMC filter ON/OFF connector to the ON position. The EMC filter is initially set to the "disabled" (OFF) position.
(For the FR-CC2-H400K or higher, two EMC filter ON/OFF connectors are provided. The both connectors are initially set to the "disabled" (OFF) position. To enable the EMC filter, fit the both EMC filter ON/OFF connectors to the ON position.)




**<How to enable or disable the filter>**

- Before removing a front cover, check to make sure that the indication of the inverter operation panel is OFF, wait for at least 10 minutes after the power supply has been switched OFF, and check that there is no residual voltage using a tester or the like.
- When disconnecting the connector, push the fixing tab and pull the connector straight without pulling the cable or forcibly pulling the connector with the tab fixed.
  When installing the connector, also engage the fixing tab securely.
  (If it is difficult to disconnect the connector, use a pair of needle-nose pliers, etc.)




**NOTE**

- Fit the connector to either ON or OFF position.
- Enabling (turning ON) the EMC filter increases leakage current. (Refer to page 61.)

**Warning**

- **While the inverter power is ON, do not open the front cover. Otherwise you may get an electric shock.**

# 3.2 Power supply harmonics

## 3.2.1 Power supply harmonics

The inverter may generate power supply harmonics from its converter circuit to affect the power generator, power factor correction capacitor etc. Power supply harmonics are different from noise and leakage currents in source, frequency band and transmission path. Take the following countermeasure suppression techniques.

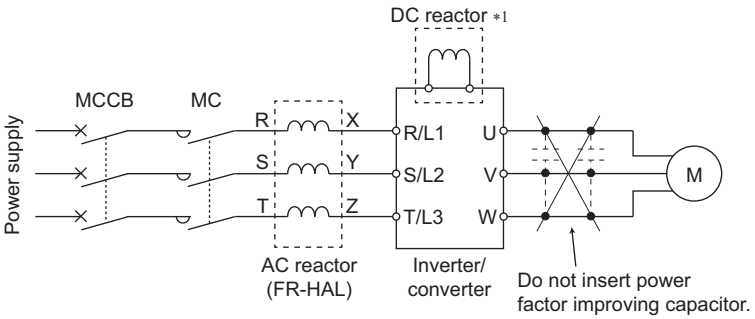
• The differences between harmonics and noises

| Item | Harmonics | Noise |
|---|---|---|
| Frequency | Normally 40th to 50th degrees or less (3 kHz or less). | High frequency (several 10 kHz to 1 GHz order). |
| Environment | To-electric channel, power impedance. | To-space, distance, wiring path, |
| Quantitative understanding | Theoretical calculation possible. | Random occurrence, quantitative grasping difficult. |
| Generated amount | Nearly proportional to the load capacity. | Changes with the current variation ratio. (Gets larger as switching speed increases.) |
| Affected equipment immunity | Specified by standards per equipment. | Different depending on maker's equipment specifications. |
| Countermeasure | Provide a reactor. | Increase distance. |

• Countermeasures

The harmonic current generated from the inverter to the input side differs according to various conditions such as the wiring impedance, whether a reactor is used or not, and output frequency and output current on the load side.

For the output frequency and output current, we understand that this should be calculated in the conditions under the rated load at the maximum operating frequency.




*1 The converter unit (FR-CC2) is equipped with the DC reactor.

**NOTE**

• The power factor improving capacitor and surge suppressor on the inverter output side may be overheated or damaged by the harmonic components of the inverter output. Also, since an excessive current flows in the inverter to activate overcurrent protection, do not provide a capacitor and surge suppressor on the inverter output side when the motor is driven by the inverter. For power factor improvement, install a reactor on the inverter input side or in the DC circuit.

# 3.2.2 Harmonic Suppression Guidelines in Japan

Harmonic currents flow from the inverter to a power receiving point via a power transformer. The Harmonic Suppression Guidelines was established to protect other consumers from these outgoing harmonic currents.

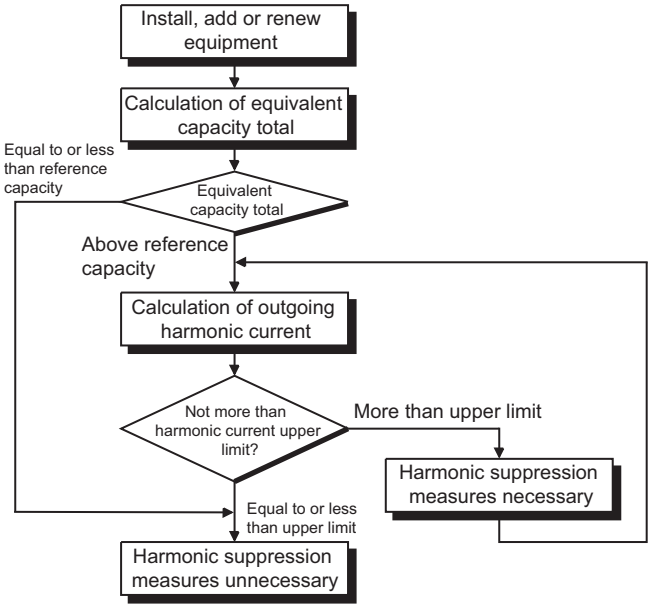
The three-phase 200 V input specifications 3.7 kW or lower were previously covered by "the Harmonic Suppression Guidelines for Household Appliances and General-purpose Products" and other models were covered by "the Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage". However, the transistorized inverter has been excluded from the target products covered by "the Harmonic Suppression Guidelines for Household Appliances and General-purpose Products" in January 2004 and "the Harmonic Suppression Guideline for Household Appliances and General-purpose Products" was repealed on September 6, 2004.

All capacity and all models of general-purpose inverter used by specific consumers are now covered by "the Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage" (hereinafter referred to as "the Specific Consumer Guidelines").

- "Specific Consumer Guidelines"
  This guideline sets forth the maximum harmonic currents outgoing from a high-voltage or especially high-voltage receiving consumer who will install, add or renew harmonic generating equipment. If any of the maximum values is exceeded, this guideline requires that consumer to take certain suppression measures.
- Maximum Values of Outgoing Harmonic Currents per 1 kW Contract Power

| Received power voltage | 5th | 7th | 11th | 13th | 17th | 19th | 23rd | Over 23rd |
|---|---|---|---|---|---|---|---|---|
| 6.6 kV | 3.5 | 2.5 | 1.6 | 1.3 | 1.0 | 0.9 | 0.76 | 0.70 |
| 22 kV | 1.8 | 1.3 | 0.82 | 0.69 | 0.53 | 0.47 | 0.39 | 0.36 |
| 33 kV | 1.2 | 0.86 | 0.55 | 0.46 | 0.35 | 0.32 | 0.26 | 0.24 |

## ◆Application of the specific consumer guidelines




- Conversion factors for FR-A800 series

| Classification | Circuit type | | Conversion coefficient Ki |
|---|---|---|---|
| 3 | Three-phase bridge (Capacitor smoothing) | With reactor (DC side) *1 | K33 = 1.8 |
| | | With reactors (AC, DC sides) *1 | K34 = 1.4 |
| 5 | Self-excitation three-phase bridge | When a high power factor converter is used | K5 = 0 |

- Equivalent Capacity Limits

| Received power voltage | Reference capacity |
|---|---|
| 6.6 kV | 50 kVA |
| 22/33 kV | 300 kVA |
| 66 kV or more | 2000 kVA |

- Harmonic content (Values of the fundamental current is 100%)

| reactor | 5th | 7th | 11th | 13th | 17th | 19th | 23rd | 25th |
|---|---|---|---|---|---|---|---|---|
| Used (DC side) *1 | 30 | 13 | 8.4 | 5.0 | 4.7 | 3.2 | 3.0 | 2.2 |
| Used (AC, DC sides) *1 | 28 | 9.1 | 7.2 | 4.1 | 3.2 | 2.4 | 1.6 | 1.4 |

*1 The converter unit (FR-CC2) is equipped with the DC reactor on its DC side.

- Calculation of equivalent capacity P0 of harmonic generating equipment

  "Equivalent capacity" is the capacity of a 6-pulse converter converted from the capacity of consumer's harmonic generating equipment and is calculated by the following equation: If the sum of equivalent capacities is higher than the limit in (refer to page 68), harmonics must be calculated with the following procedure:

  P0 = ∑ (Ki × Pi) [kVA]

  Ki: Conversion coefficient (Refer to page 68)

  Pi: Rated capacity*2 of harmonic generating equipment [kVA]

  i: Number indicating the conversion circuit type

*2 Rated capacity: Determined by the capacity of the applied motor and found in Table 5. The rated capacity used here is used to calculate the generated harmonic amount and is different from the power supply capacity required for actual inverter drive.

- Calculation of outgoing harmonic current

  Outgoing harmonic current = fundamental wave current (value converted from received power voltage) × operation ratio × harmonic content

  - Operation ratio: Operation ratio = actual load factor × operation time ratio during 30 minutes
  - Harmonic content: Found in page 68.

- Rated capacities and outgoing harmonic currents of inverter-driven motors

| Applicable motor (kW) | Rated current (A) | Fundamental wave current converted from 6.6 kV (mA) | Rated capacity (kVA) | Outgoing harmonic current converted from 6.6 kV (mA) (With a DC reactor, 100% operation ratio) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 400 V | | | 5th | 7th | 11th | 13th | 17th | 19th | 23rd | 25th |
| 75 | 123 | 7455 | 87.2 | 2237 | 969 | 626 | 373 | 350 | 239 | 224 | 164 |
| 90 | 147 | 8909 | 104 | 2673 | 1158 | 748 | 445 | 419 | 285 | 267 | 196 |
| 110 | 179 | 10848 | 127 | 3254 | 1410 | 911 | 542 | 510 | 347 | 325 | 239 |
| 132 | 216 | 13091 | 153 | 3927 | 1702 | 1100 | 655 | 615 | 419 | 393 | 288 |
| 160 | 258 | 15636 | 183 | 4691 | 2033 | 1313 | 782 | 735 | 500 | 469 | 344 |
| 220 | 355 | 21515 | 252 | 6455 | 2797 | 1807 | 1076 | 1011 | 688 | 645 | 473 |
| 250 | 403 | 24424 | 286 | 7327 | 3175 | 2052 | 1221 | 1148 | 782 | 733 | 537 |
| 280 | 450 | 27273 | 319 | 8182 | 3545 | 2291 | 1364 | 1282 | 873 | 818 | 600 |
| 315 | 506 | 30667 | 359 | 9200 | 3987 | 2576 | 1533 | 1441 | 981 | 920 | 675 |
| 355 | 571 | 34606 | 405 | 10382 | 4499 | 2907 | 1730 | 1627 | 1107 | 1038 | 761 |
| 400 | 643 | 38970 | 456 | 11691 | 5066 | 3274 | 1949 | 1832 | 1247 | 1169 | 857 |
| 450 | 723 | 43818 | 512 | 13146 | 5696 | 3681 | 2191 | 2060 | 1402 | 1315 | 964 |
| 500 | 804 | 48727 | 570 | 14618 | 6335 | 4093 | 2436 | 2290 | 1559 | 1462 | 1072 |
| 560 | 900 | 54545 | 638 | 16364 | 7091 | 4582 | 2727 | 2564 | 1746 | 1636 | 1200 |

- Determining if a countermeasure is required

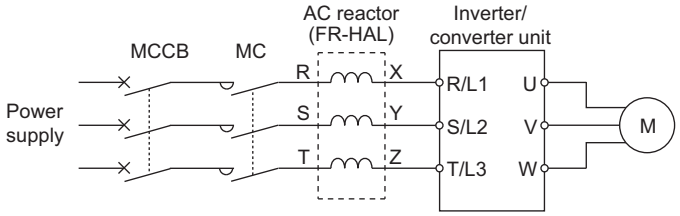
  A countermeasure for harmonics is required if the following condition is satisfied: outgoing harmonic current > maximum value per 1 kW contract power × contract power.

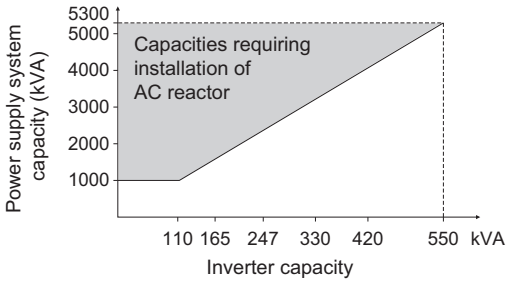
- Harmonic suppression techniques

| No. | Item | Description |
|---|---|---|
| 1 | Reactor installation (FR-HAL) | The converter unit (FR-CC2) is equipped with the DC reactor on its DC side, and outgoing harmonic current can be suppressed. By installing an AC reactor (FR-HAL) on the AC side of the inverter, the outgoing harmonic current suppression performance can be improved. |
| 2 | high power factor converter (FR-HC2) | This converter trims the current waveform to be a sine waveform by switching the rectifier circuit (converter module) with transistors. Doing so suppresses the generated harmonic amount significantly. Connect it to the DC area of an inverter. Use the high power factor converter (FR-HC2) with the accessories that come as standard. |
| 3 | Installation of power factor improving capacitor | When used with a reactor connected in series, the power factor improving correction capacitor can absorb harmonic currents. |
| 4 | Transformer multi-phase operation | Use two transformers with a phase angle difference of 30° as in 人-Δ and Δ-Δ combinations to provide an effect corresponding to 12 pulses, reducing low-degree harmonic currents. |
| 5 | Passive filter (AC filter) | A capacitor and a reactor are used together to reduce impedances at specific frequencies. Harmonic currents are expected to be absorbed greatly by using this technique. |
| 6 | Active filter (Active filter) | This filter detects the current in a circuit generating a harmonic current and generates a harmonic current equivalent to a difference between that current and a fundamental wave current to suppress the harmonic current at the detection point. Harmonic currents are expected to be absorbed greatly by using this technique. |

# 3.3 Installation of a reactor

When the inverter is connected near a large-capacity power transformer (1000 kVA or more) or when a power factor correction capacitor is to be switched over, an excessive peak current may flow in the power input circuit, damaging the converter circuit. To prevent this, always install an optional AC reactor (FR-HAL).



# 3.4 Power-OFF and magnetic contactor (MC)

## ◆Converter unit input side magnetic contactor (MC)

On the converter unit input side, it is recommended to provide an MC for the following purposes:
(Refer to page 14 for selection.)

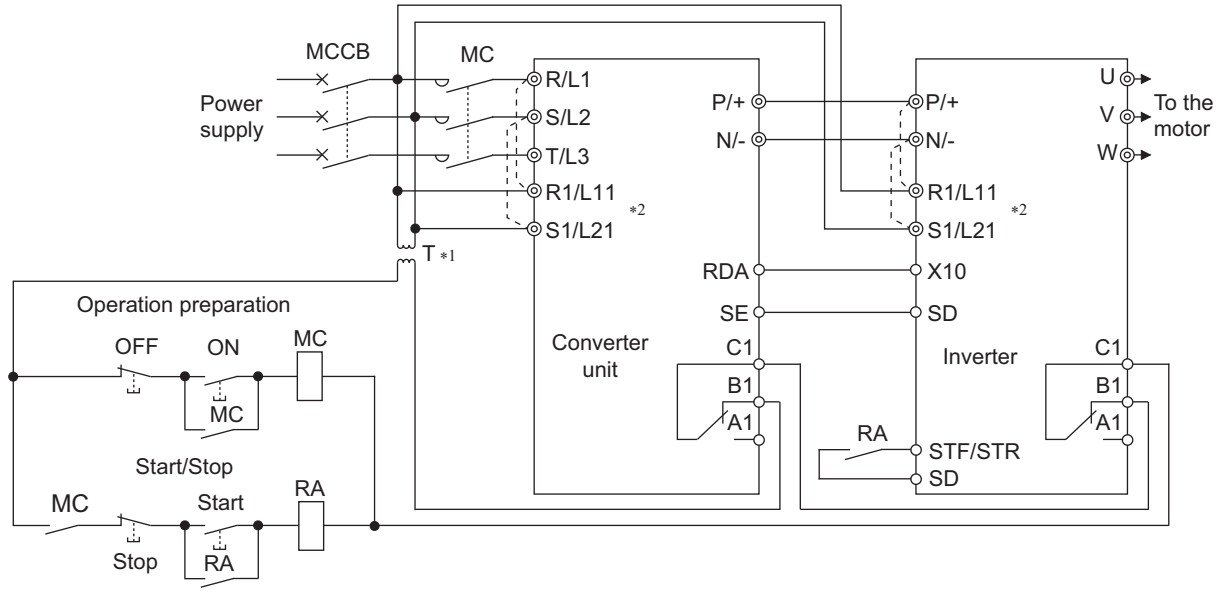
- To disconnect the inverter from the power supply at activation of a protective function or at malfunctioning of the driving system (emergency stop, etc.).
- To prevent any accident due to an automatic restart at power restoration after an inverter stop made by a power failure.
- To separate the inverter from the power supply to ensure safe maintenance and inspection work.

If using an MC for emergency stop during operation, select an MC regarding the converter unit input side current as JEM1038-AC-3 class rated current.

**NOTE**

- Since repeated inrush currents at power ON will shorten the life of the converter circuit (switching life is about 1,000,000 times), frequent starts and stops of the magnetic contactor must be avoided. Turn ON/OFF the inverter start controlling terminals (STF, STR) to run/stop the inverter.

- Inverter start/stop circuit example
  As shown below, always use the start signal (ON or OFF of STF(STR) signal) to make a start or stop.




*1 When the power supply is 400 V class, install a stepdown transformer.

*2 Connect the power supply terminals R1/L11, S1/L21 of the control circuit to the input side of the MC to hold an alarm signal when the inverter's protective circuit is activated. At this time, remove jumpers across terminals R1/L11 and S1/L21. (Refer to page 43 for removal of the jumper.)

## ◆Handling of the magnetic contactor on the inverter's output side

Switch the magnetic contactor between the inverter and motor only when both the inverter and motor are at a stop. When the magnetic contactor is turned ON while the inverter is operating, overcurrent protection of the inverter and such will activate. When an MC is provided to switch to a commercial power supply, for example, it is recommended to use the commercial power supply-inverter switchover function **Pr.135 to Pr.139**. (The commercial power supply operation is not available with vector control dedicated motors nor with PM motors.)

## ◆Handling of the manual contactor on the inverter's output side

A PM motor is a synchronous motor with high-performance magnets embedded inside. High-voltage is generated at the motor terminals while the motor is running even after the inverter power is turned OFF. In an application where the PM motor is driven by the load even after the inverter is powered OFF, a low-voltage manual contactor must be connected at the inverter's output side.

NOTE

- Before wiring or inspection for a PM motor, confirm that the PM motor is stopped. In an application, such as fan and blower, where the motor is driven by the load, a low-voltage manual contactor must be connected at the inverter's output side, and wiring and inspection must be performed while the contactor is open. Otherwise you may get an electric shock.
- Do not open or close the contactor while the inverter is running (outputting).

# 3.5 Countermeasures against deterioration of the 400 V class motor insulation

In the PWM type inverter, a surge voltage attributable to wiring constants is generated at the motor terminals. Especially in a 400 V class motor, the surge voltage may deteriorate the insulation. When the 400 V class motor is driven by the inverter, consider the following countermeasures:

• Countermeasures

(With induction motor)

It is recommended to take one of the following countermeasures:

- Rectifying the motor insulation and limiting the PWM carrier frequency according to the wiring length
  For the 400 V class motor, use an insulation-enhanced motor.
  Specifically,
  - Order a "400 V class inverter-driven insulation-enhanced motor".
  - For the dedicated motor such as the constant-torque motor and low-vibration motor, use an "inverter-driven dedicated motor".
  - Set **Pr.72 PWM frequency selection** as indicated below according to the wiring length.

| | Wiring length | |
|---|---|---|
| | **100 m or shorter** | **Longer than 100 m** |
| **Pr.72 PWM frequency selection** | 6 (6 kHz) or lower | 4 (4 kHz) or lower |

- Suppressing the surge voltage on the inverter side
  - If the motor capacity is 280 kW or lower, connect the sine wave filter (MT-BSL/BSC) to the output side.

(With PM motor)

- When the wiring length exceeds 50 m, set "9" (6 kHz) or less in **Pr.72 PWM frequency selection**.

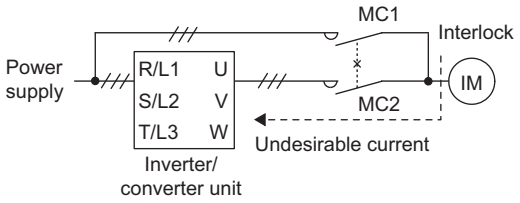
NOTE

- When using the optional sine wave filter (MT-BSL/BSC), set **Pr.72**="25" (2.5 kHz).
- For the details of the sine wave filter (MT-BSL/BSC), refer to the Instruction Manual of each option.
- A sine wave filter (MT-BSL/BSC) can be used under V/F control. Do not use the filters under different control methods.
- The carrier frequency is limited during PM sensorless vector control. (Refer to the FR-A800 Instruction Manual (Detailed))

# 3.6 Checklist before starting operation

The FR-A800 series inverter and FR-CC2 converter unit are highly reliable products, but incorrect peripheral circuit making or operation/handling method may shorten the product life or damage the products.
Before starting operation, always recheck the following points.

| Checkpoint | Countermeasure | Refer to page | Check by user |
|---|---|---|---|
| Crimping terminals are insulated. | Use crimping terminals with insulation sleeves to wire the power supply and the motor. | - | |
| The wiring between the power supply (R/L1, S/L2, T/L3) and the motor (U, V, W) is correct. | Application of power to the output terminals (U, V, W) of the inverter will damage the inverter. Never perform such wiring. | 29 | |
| No wire offcuts are left from the time of wiring. | Wire offcuts can cause an alarm, failure or malfunction. Always keep the inverter and the converter unit clean.<br>When drilling mounting holes in an enclosure etc., take caution not to allow chips and other foreign matter to enter the inverter and the converter unit. | - | |
| The main circuit cable gauge is correctly selected. | Use an appropriate cable gauge to suppress the voltage drop to 2% or less. If the wiring distance is long between the inverter and motor, a voltage drop in the main circuit will cause the motor torque to decrease especially during the output of a low frequency. | 30 | |
| The total wiring length within the specified length. | Keep the total wiring length is within the specified length.<br>In long distance wiring, charging currents due to stray capacitance in the wiring may degrade the fast-response current limit operation or cause the equipment on the inverter's output side to malfunction. Pay attention to the total wiring length. | 30 | |
| Countermeasures are taken against EMI. | The input/output (main circuit) of the inverter and the converter unit includes high frequency components, which may interfere with the communication devices (such as AM radios) used near the inverter and the converter unit. In such case, activate the EMC filter (turn ON the EMC filter ON/OFF connector) to minimize interference. | 66 | |
| On the inverter's output side, none of the power factor correction capacitor, surge suppressor, or radio noise filter is installed. | Doing so will cause the inverter to trip or the capacitor and surge suppressor to be damaged. If any of the above devices is connected, immediately remove it. | - | |
| When performing an inspection or rewiring on the product that has been energized, the operator has waited long enough after shutting off the power supply. | For a short time after the power-OFF, a high voltage remains in the smoothing capacitor, and it is dangerous.<br>Before performing an inspection or rewiring, wait 10 minutes or longer after the power supply turns OFF, then confirm that the voltage across the main circuit terminals P/+ and N/- of the inverter is low enough using a tester, etc. | - | |
| The inverter's output side has no short circuit or ground fault occurring. | • A short circuit or earth (ground) fault on the inverter's output side may damage the inverter module.<br>• Fully check the insulation resistance of the circuit prior to inverter operation since repeated short circuits caused by peripheral circuit inadequacy or an earth (ground) fault caused by wiring inadequacy or reduced motor insulation resistance may damage the inverter module.<br>• Fully check the to-earth (ground) insulation and phase-to-phase insulation of the inverter's output side before power-ON. Especially for an old motor or use in hostile atmosphere, securely check the motor insulation resistance, etc. | - | |
| The circuit is not configured to use the converter unit's input-side magnetic contactor to start/stop the inverter frequently. | Since repeated inrush currents at power ON will shorten the life of the inverter and the converter unit, frequent starts and stops of the magnetic contactor must be avoided. Turn ON/OFF the inverter's start signals (STF, STR) to run/stop the inverter. | 71 | |
| The voltage applied to the I/O signal circuits of the inverter and the converter unit is within the specifications. | Application of a voltage higher than the permissible voltage to the I/O signal circuits of the inverter and the converter unit or opposite polarity may damage the I/O devices. Especially check the wiring to prevent the speed setting potentiometer from being connected incorrectly to short circuit the terminals 10E and 5. | 33 | |

| Checkpoint | Countermeasure | Refer to page | Check by user |
|---|---|---|---|
| The converter unit and the inverter are correctly connected. | • Make sure that the terminal P/+ of the converter unit and the terminal P/+ of the inverter, and the terminal N/- of the converter unit and the terminal N- of the inverter are correctly connected.<br>Connecting the opposite polarity of terminals N/- and P/+ will damage the inverter.<br>Also, do not install an MCCB across the terminals P/+ and N/- (across terminals P and P/+ or across N and N/-).<br>• Always connect the terminal RDA of the converter unit and the terminal MRS (X10) of the inverter, and the terminal SE of the converter unit and the terminal SD (terminal PC for source logic) of the inverter.<br>Not connecting these terminals may damage the converter unit. | 27 | |
| When using the electronic bypass operation, electrical and mechanical interlocks are provided between the electronic bypass contactors MC1 and MC2. | When using a switching circuit as shown below, chattering due to mis-configured sequence or arc generated at switching may allow undesirable current to flow in and damage the inverter. Mis-wiring may also damage the inverter.<br>(The commercial power supply operation is not available with vector control dedicated motors nor with PM motors.)<br>  <br>When switching to the commercial power supply operation while a failure such as an output short circuit is occurring between the magnetic contactor MC2 and the motor, the damage may further spread.<br>When a failure occurs between the MC2 and motor, make sure to provide a protection circuit, such as using the OH signal input. | - | |
| A countermeasure is provided for power restoration after a power failure. | If the machine must not be restarted when power is restored after a power failure, provide an MC in the converter unit's input side and also make up a sequence which will not switch ON the start signal. If the start signal (start switch) remains ON after a power failure, the inverter will automatically restart as soon as the power is restored. | - | |
| Wheng using the vector control, the encoder is properly installed. | The encoder must be directly connected to a motor shaft without any backlash. (Real sensorless vector control, PM sensorless vector control do not require an encoder.) | 50 | |
| A magnetic contactor (MC) is installed on the converter unit's input side. | On the converter unit's input side, connect an MC for the following purposes:<br>• To disconnect the inverter and the converter unit from the power supply at activation of a protective function or at malfunctioning of the driving system (emergency stop, etc.).<br>• To prevent any accident due to an automatic restart at power restoration after an inverter stop made by a power failure.<br>• To separate the inverter and the converter unit from the power supply to ensure safe maintenance and inspection work.<br>If using an MC for emergency stop during operation, select an MC regarding the converter unit input side current as JEM1038-AC-3 class rated current. | 71 | |
| The magnetic contactor on the inverter's output side is properly handled. | Switch the magnetic contactor between the inverter and motor only when both the inverter and motor are at a stop. | 71 | |
| When using a PM motor, a low-voltage manual contactor is installed on the inverter's output side. | A PM motor is a synchronous motor with high-performance magnets embedded inside. High-voltage is generated at the motor terminals while the motor is running even after the inverter power is turned OFF. In an application, such as fan and blower, where the motor is driven by the load, a low-voltage manual contactor must be connected at the inverter's output side, and wiring and inspection must be performed while the contactor is open. Otherwise you may get an electric shock. | 71 | |
| An EMI countermeasure is provided for the frequency setting signals. | If electromagnetic noise generated from the inverter and the converter unit causes frequency setting signal to fluctuate and the motor rotation speed to be unstable when changing the motor speed with analog signals, the following countermeasures are effective:<br>• Do not run the signal cables and power cables (inverter and converter unit I/O cables) in parallel with each other and do not bundle them.<br>• Run signal cables as far away as possible from power cables (inverter and converter I/O cables).<br>• Use shielded cables.<br>• Install a ferrite core on the signal cable (Example: ZCAT3035-1330 TDK). | - | |

| Checkpoint | Countermeasure | Refer to page | Check by user |
|---|---|---|---|
| A countermeasure is provided for an overload operation. | When performing frequent starts/stops by the inverter, rise/fall in the temperature of the transistor element of the inverter will repeat due to a repeated flow of large current, shortening the life from thermal fatigue. Since thermal fatigue is related to the amount of current, the life can be increased by reducing current at locked condition, starting current, etc. Reducing current may extend the service life but may also cause torque shortage, which leads to a start failure. Adding a margin to the current can eliminate such a condition. For an induction motor, use the inverter and the converter unit of a higher capacity (up to two ranks). For a PM motor, use the inverter and the converter unit, and PM motor of higher capacities. | - | |
| The specifications and rating match the system requirements. | Make sure that the specifications and rating match the system requirements. | - | |

# 3.7 Failsafe system which uses the inverter

When a fault is detected by the protective function, the protective function activates and outputs a fault signal. However, a fault signal may not be output at an inverter's fault occurrence when the detection circuit or output circuit fails, etc. Although Mitsubishi assures the best quality products, provide an interlock which uses inverter status output signals to prevent accidents such as damage to the machine when the inverter fails for some reason. Also at the same time consider the system configuration where a failsafe from outside the inverter, without using the inverter, is enabled even if the inverter fails.

## ◆Interlock method which uses the inverter status output signals

By combining the inverter output signals to provide an interlock as shown below, an inverter failure can be detected.

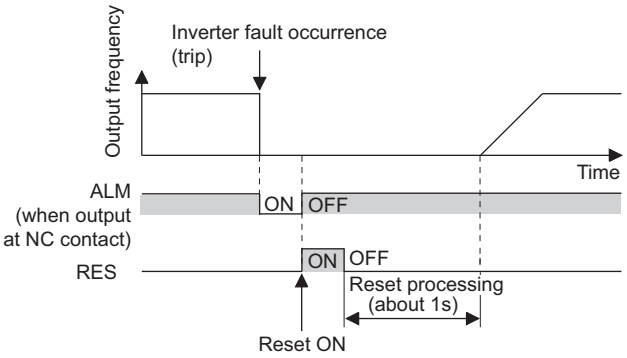
| No. | Interlock method | Check method | Used signals |
|---|---|---|---|
| a | Inverter protective function operation | Operation check of an alarm contact.<br>Circuit error detection by negative logic. | Fault output signal (ALM signal) |
| b | Inverter operating status | Operation ready signal check. | Operation ready signal (RY signal) |
| c | Inverter running status | Logic check of the start signal and running signal. | Start signal (STF signal, STR signal)<br>Running signal (RUN signal) |
| d | Inverter running status | Logic check of the start signal and output current. | Start signal (STF signal, STR signal)<br>Output current detection signal (Y12 signal) |

(a) Checking by the output of the inverter fault signal

When the inverter's protective function activates and the inverter trips, the fault output signal (ALM signal) is output. (ALM signal is assigned to terminal A1B1C1 in the initial setting).

With this signal, check that the inverter operates properly.

In addition, negative logic can be set. (ON when the inverter is normal, OFF when the fault occurs.)




(b) Checking the inverter operating status by the inverter operation ready completion signal

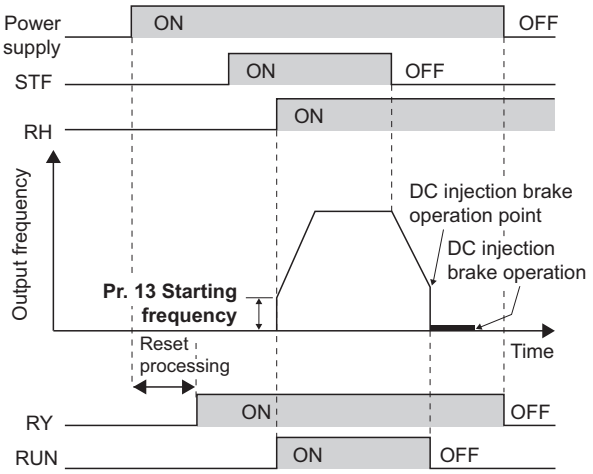
Operation ready signal (RY signal) is output when the inverter power is ON and the inverter becomes operative.

Check if the RY signal is output after powering ON the inverter.

(c) Checking the inverter operating status by the start signal input to the inverter and inverter running signal

The inverter running signal (RUN signal) is output when the inverter is running. (RUN signal is assigned to terminal RUN in the initial setting.)

Check if Y12 signal is being output while inputting a start signal to the inverter. (STF signal is a forward rotation signal, and STR is a reverse rotation signal.) Even after the start signal is turned OFF, the RUN signal is kept output until the inverter makes the motor to decelerate and to stop. For the logic check, configure a sequence considering the inverter's deceleration time.



(d) Checking the motor operating status by the start signal input to the inverter and inverter output current detection signal
The output current detection signal (Y12 signal) is output when the inverter operates and current flows into the motor. Check if Y12 signal is being output while inputting a start signal to the inverter. (STF signal is a forward rotation signal, and STR is a reverse rotation signal.) The Y12 signal is initially set to be output at 150% rated inverter current. Adjust the level to around 20% using no load current of the motor as reference with **Pr.150 Output current detection level**. Like the inverter running signal (RUN signal), even after the start signal is turned OFF, the Y12 signal is kept output until the inverter stops the output to a decelerating motor. For the logic check, configure a sequence considering the inverter's deceleration time.

| Output signal | Pr.190 to Pr.196 setting | |
|---|---|---|
| | Positive logic | Negative logic |
| ALM | 99 | 199 |
| RY | 11 | 111 |
| RUN | 0 | 100 |
| Y12 | 12 | 112 |

- When using various signals, assign the functions to **Pr.190 and Pr.196 (output terminal function selection)** referring to the table on the left.

**NOTE**

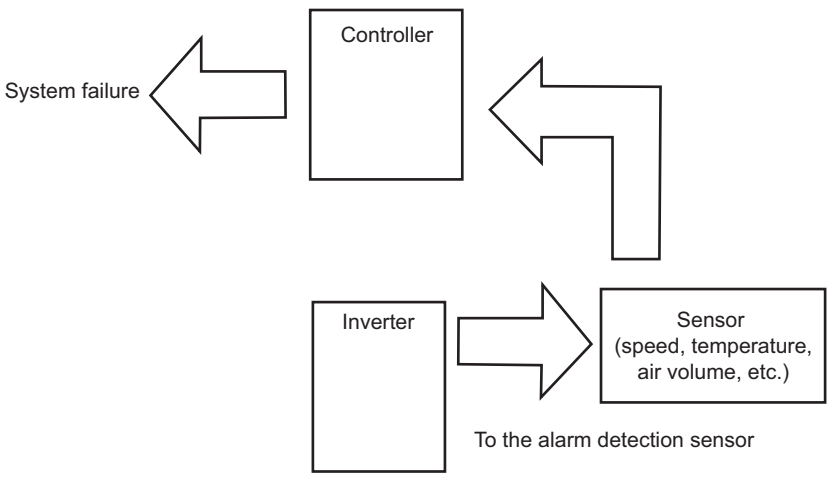
- Changing the terminal assignment using **Pr.190 and Pr.196 (output terminal function selection)** may affect the other functions. Set parameters after confirming the function of each terminal.
- For the details of the parameters and signals, refer to the FR-A800 Instruction Manual (Detailed).

## ◆Backup method outside the inverter

Even if the interlock is provided by the inverter status signal, enough failsafe is not ensured depending on the failure status of the inverter itself. For example, if an inverter CPU fails in a system interlocked with the inverter's fault, start, and RUN signals, no fault signal will be output and the RUN signal will be kept ON because the inverter CPU is down.
Provide a speed detector to detect the motor speed and current detector to detect the motor current and consider the backup system such as performing a check as below according to the level of importance of the system.

(a) Start signal and actual operation check
Check the motor running and motor current while the start signal is input to the inverter by comparing the start signal to the inverter and detected speed of the speed detector or detected current of the current detector. Note that the current is flowing through the motor while the motor coasts to stop, even after the inverter's start signal is turned OFF. For the logic check, configure a sequence considering the inverter's deceleration time. In addition, it is recommended to check the three-phase current when using the current detector.

(b) Command speed and actual operation check
Check for a gap between the actual speed and commanded speed by comparing the inverter's speed command and the speed detected by the speed detector.



MEMO

# 4 PROTECTIVE FUNCTIONS

This chapter explains the "PROTECTIVE FUNCTIONS" that operates in this product.
Always read the instructions before using the equipment.


**4.1 Inverter fault and alarm indications .....80**
**4.2 Reset method for the protective functions.....80**
**4.3 Check and clear of the faults history .....81**
**4.4 List of fault displays .....83**

# 4.1 Inverter fault and alarm indications

- When the inverter detects a fault, depending on the nature of the fault, the operation panel displays an error message or warning, or a protective function activates to trip the inverter.
- When any fault occurs, take an appropriate corrective action, then reset the inverter, and resume the operation. Restarting the operation without a reset may break or damage the inverter.
- When a protective function activates, note the following points.

| Item | Description |
|---|---|
| Fault output signal | Opening the magnetic contactor (MC) provided on the input side of the inverter at a fault occurrence shuts off the control power to the inverter, therefore, the fault output will not be retained. |
| Fault or alarm indication | When a protective function activates, the operation panel displays a fault indication. |
| Operation restart method | While a protective function is activated, the inverter output is kept shutoff. Reset the inverter to restart the operation. |

- Inverter fault or alarm indications are categorized as below.

| Displayed item | Description |
|---|---|
| Error message | A message regarding an operational fault and setting fault by the operation panel (FR-DU08) and parameter unit (FR-PU07) is displayed. The inverter does not trip. |
| Warning | The inverter does not trip even when a warning is displayed. However, failure to take appropriate measures will lead to a fault. |
| Alarm | The inverter does not trip. An Alarm (LF) signal can also be output with a parameter setting. |
| Fault | A protective function activates to trip the inverter and output a Fault (ALM) signal. |

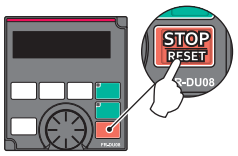
**NOTE**

- For the details of fault displays and other malfunctions, refer to the FR-A800 Instruction Manual (Detailed).
- The past eight faults can be displayed on the operation panel. (Faults history) (For the operation, refer to page 81.)

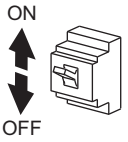
# 4.2 Reset method for the protective functions

Reset the inverter by performing any of the following operations. Note that the accumulated heat value of the electronic thermal relay function and the number of retries are cleared (erased) by resetting the inverter.
The inverter recovers about 1 s after the reset is released.

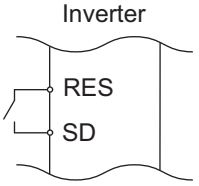
- On the operation panel, press STOP RESET to reset the inverter.
  (This may only be performed when a fault occurs.)




- Switch power OFF once, then switch it ON again.




- Turn ON the reset signal (RES) for 0.1 s or more. (If the RES signal is kept ON, "Err" appears (flickers) to indicate that the inverter is in a reset status.)



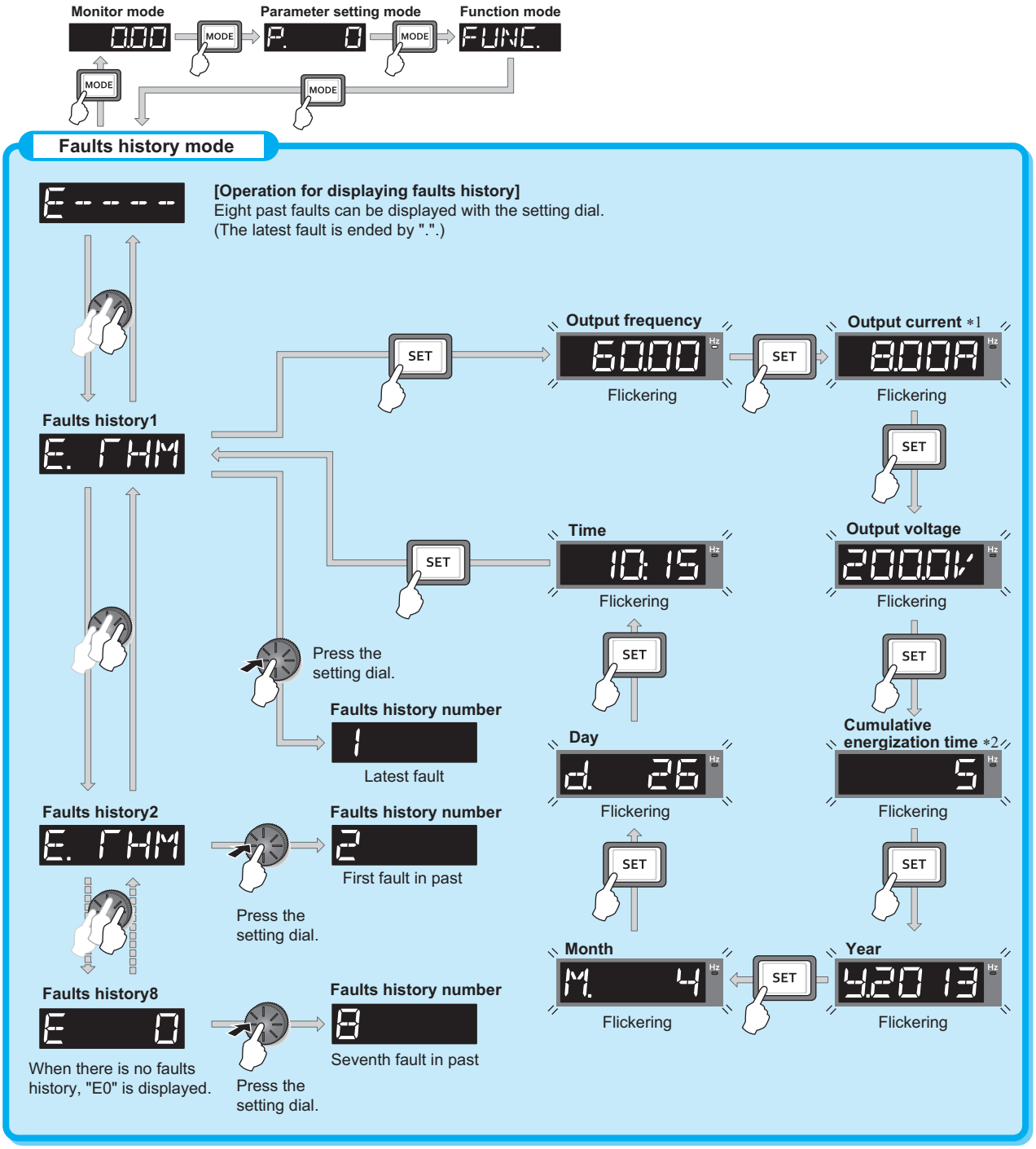

**NOTE**

- OFF status of the start signal must be confirmed before resetting the inverter fault. Resetting an inverter fault with the start signal ON restarts the motor suddenly.

# 4.3 Check and clear of the faults history

The operation panel stores the fault indications which appears when a protective function is activated to display the fault record for the past eight faults. (Faults history)

## ◆Check for the faults history




∗1 When an overcurrent trip occurs by an instantaneous overcurrent, the monitored current value saved in the faults history may be lower than the actual current that has flowed.

∗2 The cumulative energization time and actual operation time are accumulated from 0 to 65535 hours, then cleared, and accumulated again from 0.

## ◆Faults history clearing procedure

**POINT**

- Set **Err.CL Fault history clear** = "1" to clear the faults history.

### Operation

**1.** Screen at power-ON

The monitor display appears.

**2.** Parameter setting mode

Press [MODE] to choose the parameter setting mode. (The parameter number read previously appears.)

**3.** Selecting the parameter number

Turn until Err.CL (faults history clear) appears. Press [SET] to read the present set value. "0" (initial value) appears.

**4.** Faults history clear

Turn to change the set value to " 1". Press [SET] to start clear.

" 1" and "Err.CL " flicker alternately after parameters are cleared.

- •Turn to read another parameter.
- •Press [SET] to show the setting again.
- •Press [SET] twice to show the next parameter.

# 4.4 List of fault displays

For details, refer to the FR-A800 Instruction Manual (Detailed).

| | Operation panel indication | | Name |
|---|---|---|---|
| Error message | E----- | E---- | Faults history |
| | HOLd | HOLD | Operation panel lock |
| | LOCd | LOCD | Password locked |
| | Er 1 to Er4 Er8 | Er1 to Er4 Er8 | Parameter write error |
| | rE 1 to rE4 rE6 to rE8 | rE1 to rE4 rE6 to rE8 | Copy operation error |
| | Err. | Err. | Error |
| Warning | OL | OL | Stall prevention (overcurrent) |
| | oL | oL | Stall prevention (overvoltage) |
| | TH | TH | Electronic thermal relay function pre-alarm |
| | PS | PS | PU stop |
| | SL | SL | Speed limit indication (output during speed limit) |
| | CP | CP | Parameter copy |
| | SA | SA | Safety stop |
| | MT 1 to MT3 | MT1 to MT3 | Maintenance timer 1 to 3 |
| | UF | UF | USB host error |
| | HP 1 | HP1 | Home position return setting error |
| | HP2 | HP2 | Home position return uncompleted |
| | HP3 | HP3 | Home position return parameter setting error |
| | EV | EV | 24 V external power supply operation |
| Alarm | FN | FN | Fan alarm |
| Fault | E. OC 1 | E.OC1 | Overcurrent trip during acceleration |
| | E. OC2 | E.OC2 | Overcurrent trip during constant speed |
| | E. OC3 | E.OC3 | Overcurrent trip during deceleration or stop |
| | E. OV 1 | E.OV1 | Regenerative overvoltage trip during acceleration |
| | E. OV2 | E.OV2 | Regenerative overvoltage trip during constant speed |
| | E. OV3 | E.OV3 | Regenerative overvoltage trip during deceleration or stop |
| | E. THT | E.THT | Inverter overload trip (electronic thermal relay function) |
| | E. THM | E.THM | Motor overload trip (electronic thermal relay function) |
| | E. FIN | E.FIN | Heatsink overheat |

| | Operation panel indication | | Name |
|---|---|---|---|
| Fault | E. OLT | E.OLT | Stall prevention stop |
| | E. SOT | E. SOT | Loss of synchronism detection |
| | E. GF | E.GF | Output side earth (ground) fault overcurrent |
| | E. LF | E.LF | Output phase loss |
| | E. OHT | E.OHT | External thermal relay operation |
| | E. PTC | E.PTC | PTC thermistor operation |
| | E. OPT | E.OPT | Option fault |
| | E. OP 1 | E.OP1 | Communication option fault |
| | E. 16 to E. 20 | E.16 to E.20 | User definition error by the PLC function |
| | E. PE | E.PE | Parameter storage device fault |
| | E. PUE | E.PUE | PU disconnection |
| | E. RET | E.RET | Retry count excess |
| | E. PE2 | E.PE2 | Parameter storage device fault |
| | E. CPU E. 5 to E. 7 | E.CPU E. 5 to E. 7/ | CPU fault |
| | E. CTE | E.CTE | Operation panel power supply short circuit RS-485 terminals power supply short circuit |
| | E. P24 | E.P24 | 24 VDC power fault |
| | E. CdO | E.CDO | Abnormal output current detection |
| | E. SER | E.SER | Communication fault (inverter) |
| | E. AIE | E.AIE | Analog input fault |
| | E. USb | E.USB | USB communication fault |
| | E. SAF | E.SAF | Safety circuit fault |
| | E. PbT E. 13 | E.PBT E.13 | Internal circuit fault |
| | E. OS | E.OS | Overspeed occurrence |
| | E. OSd | E.OSD | Speed deviation excess detection |
| | E. ECT | E.ECT | Signal loss detection |
| | E. Od | E.OD | Excessive position fault |
| | E. MB 1 to E. MB7 | E.MB1 to E.MB7 | Brake sequence fault |
| | E. EP | E.EP | Encoder phase fault |
| | E. LCI | E.LCI | 4 mA input fault |

## List of fault displays

| Operation panel indication | | | Name |
|---|---|---|---|
| Fault | E. PCH | E.PCH | Pre-charge fault |
| | E. PId | E.PID | PID signal fault |
| | E. 1<br>to<br>E. 3 | E. 1 to E. 3 | Option fault |
| | E. 11 | E.11 | Opposite rotation deceleration fault |

If faults other than the above appear, contact your sales representative.

# 5 PRECAUTIONS FOR MAINTENANCE AND INSPECTION

This chapter explains the "PRECAUTIONS FOR MAINTENANCE AND INSPECTION" for this product.
Always read the instructions before using the equipment.


**5.1 Inspection item.....86**
**5.2 Measurement of main circuit voltages, currents and powers .....92**

The inverter is a static unit mainly consisting of semiconductor devices. Daily inspection must be performed to prevent any fault from occurring due to the adverse effects of the operating environment, such as temperature, humidity, dust, dirt and vibration, changes in the parts with time, service life, and other factors.

**●Precautions for maintenance and inspection**

When accessing the inverter for inspection, wait for at least 10 minutes after the power supply has been switched OFF, and then make sure that the voltage across the main circuit terminals P/+ and N/- of the inverter is not more than 30 VDC using a tester, etc.

# 5.1 Inspection item

## 5.1.1 Daily inspection

Basically, check for the following faults during operation.

- Motor operation fault
- Improper installation environment
- Cooling system fault
- Abnormal vibration, abnormal noise
- Abnormal overheat, discoloration

## 5.1.2 Periodic inspection

Check the areas inaccessible during operation and requiring periodic inspection.
Consult us for periodic inspection.

- Check and clean the cooling system..... Clean the air filter, etc.
- Check the tightening and retighten..... The screws and bolts may become loose due to vibration, temperature changes, etc. Check and tighten them.
  Tighten them according to the specified tightening torque. (Refer to page 30.)
- Check the conductors and insulating materials for corrosion and damage.
- Measure the insulation resistance.
- Check and change the cooling fan and relay.

**NOTE**

- When using the safety stop function, periodic inspection is required to confirm that safety function of the safety system operates correctly.
  For more details, refer to the Safety Stop Function Instruction Manual (BCN-A23228-001).

# 5.1.3 Daily and periodic inspection

| Area of inspection | Inspection item | | Description | Inspection interval | | Corrective action at fault occurrence | Check by the user |
|---|---|---|---|---|---|---|---|
| | | | | Daily | Periodic *3 | | |
| General | Surrounding environment | | Check the surrounding air temperature, humidity, dirt, corrosive gas, oil mist, etc. | ○ | | Improve the environment. | |
| | Overall unit | | Check for unusual vibration and noise. | ○ | | Check fault location and retighten. | |
| | | | Check for dirt, oil, and other foreign material.*1 | ○ | | Clean. | |
| | Power supply voltage | | Check that the main circuit voltages and control voltages are normal.*2 | ○ | | Inspect the power supply. | |
| Main circuit | General | | (1) Check with megger (across main circuit terminals and earth (ground) terminal). | | ○ | Contact the manufacturer. | |
| | | | (2) Check for loose screws and bolts. | | ○ | Retighten. | |
| | | | (3) Check for overheat traces on the parts. | | ○ | Contact the manufacturer. | |
| | | | (4) Check for stain. | | ○ | Clean. | |
| | Conductors, cables | | (1) Check conductors for distortion. | | ○ | Contact the manufacturer. | |
| | | | (2) Check cable sheaths for breakage and deterioration (crack, discoloration, etc.). | | ○ | Contact the manufacturer. | |
| | Transformer/ reactor | | Check for unusual odor and abnormal increase of whining sound. | ○ | | Stop the equipment and contact the manufacturer. | |
| | Terminal block | | Check for a damage. | | ○ | Stop the equipment and contact the manufacturer. | |
| | Smoothing aluminum electrolytic capacitor | | (1) Check for liquid leakage. | | ○ | Contact the manufacturer. | |
| | | | (2) Check for safety valve projection and bulge. | | ○ | Contact the manufacturer. | |
| | | | (3) Judge by visual check | | ○ | | |
| | Relay/contactor | | Check that the operation is normal and no chattering sound is heard. | | ○ | Contact the manufacturer. | |
| Control circuit, protective circuit | Operation check | | (1) Check that the output voltages across phases are balanced while operating the inverter alone. | | ○ | Contact the manufacturer. | |
| | | | (2) Check that no fault is found in protective and display circuits in a sequence protective operation test. | | ○ | Contact the manufacturer. | |
| | Components check | Overall | (1) Check for unusual odor and discoloration. | | ○ | Stop the equipment and contact the manufacturer. | |
| | | | (2) Check for serious rust development. | | ○ | Contact the manufacturer. | |
| | | Aluminum electrolytic capacitor | (1) Check for liquid leakage in a capacitor and deformation trace. | | ○ | Contact the manufacturer. | |
| | | | (2) Visual check and judge by the life check of the control circuit capacitor. (Refer to the FR-A800 Instruction Manual (Detailed)). | | ○ | | |
| Cooling system | Cooling fan | | (1) Check for unusual vibration and noise. | ○ | | Replace the fan. | |
| | | | (2) Check for loose screws and bolts. | | ○ | Fix with the fan cover fixing screws | |
| | | | (3) Check for stain. | | ○ | Clean. | |
| | Heatsink | | (1) Check for clogging. | | ○ | Clean. | |
| | | | (2) Check for stain. | | ○ | Clean. | |
| Display | Indication | | (1) Check that display is normal. | ○ | | Contact the manufacturer. | |
| | | | (2) Check for stain. | | ○ | Clean. | |
| | Meter | | Check that reading is normal. | ○ | | Stop the equipment and contact the manufacturer. | |
| Load motor | Operation check | | Check for vibration and abnormal increase in operation noise. | ○ | | Stop the equipment and contact the manufacturer. | |

*1 Oil component of the heat dissipation grease used inside the inverter may leak out. The oil component, however, is not flammable, corrosive, nor conductive and is not harmful to humans. Wipe off such oil component.

*2 It is recommended to install a voltage monitoring device for checking the voltage of the power supplied to the inverter.

*3 One to two years of periodic inspection cycle is recommended. However, it differs according to the installation environment. Consult us for periodic inspection.

NOTE

- Continuous use of a leaked, deformed, or degraded smoothing aluminum electrolytic capacitor (as shown in the table above) may lead to a burst, breakage or fire. Replace such capacitor without delay.

# 5.1.4 Checking the inverter and converter modules

## ◆Preparation

- Disconnect the external power supply cables (R/L1, S/L2, T/L3) and motor cables (U, V, W). (The inverter and the converter unit (FR-CC2) can be measured with those cables connected.)
- Prepare a tester. (For the resistance measurement, use the 100 Ω range.)

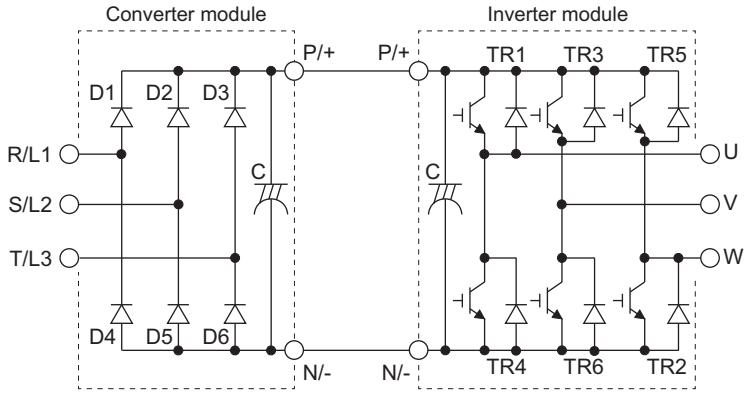
## ◆Checking method

Change the polarity of the tester alternately at the inverter terminals R/L1, S/L2, T/L3, U, V, W, P/+, and N/- and check the electric continuity.

**NOTE**

- Before measurement, check that the smoothing capacitor is discharged.
- At the time of electric discontinuity, the measured value is almost ∞. When there is an instantaneous electric continuity, due to the smoothing capacitor, the tester may not indicate ∞. At the time of electric continuity, the measured value is several Ω to several tens of Ω. If all measured values are almost the same, although these values are not constant depending on the module type and tester type, the modules are without fault.

## ◆Module device numbers and terminals to be checked




| | | Tester polarity ⊕ | Tester polarity ⊖ | Result | | Tester polarity ⊕ | Tester polarity ⊖ | Result |
|---|---|---|---|---|---|---|---|---|
| Converter module | D1 | R/L1, | P/+ | Discontinuity | D4 | R/L1, | N/- | Continuity |
| | | P/+ | R/L1, | Continuity | | N/- | R/L1, | Discontinuity |
| | D2 | S/L2, | P/+ | Discontinuity | D5 | S/L2, | N/- | Continuity |
| | | P/+ | S/L2, | Continuity | | N/- | S/L2, | Discontinuity |
| | D3 | T/L3 | P/+ | Discontinuity | D6 | T/L3 | N/- | Continuity |
| | | P/+ | T/L3 | Continuity | | N/- | T/L3 | Discontinuity |
| Inverter module | TR1 | U | P/+ | Discontinuity | TR4 | U | N/- | Continuity |
| | | P/+ | U | Continuity | | N/- | U | Discontinuity |
| | TR3 | V | P/+ | Discontinuity | TR6 | V | N/- | Continuity |
| | | P/+ | V | Continuity | | N/- | V | Discontinuity |
| | TR5 | W | P/+ | Discontinuity | TR2 | W | N/- | Continuity |
| | | P/+ | W | Continuity | | N/- | W | Discontinuity |

(Assumes the use of an analog meter.)

## 5.1.5 Cleaning

Always run the inverter in a clean status.

When cleaning the inverter, gently wipe dirty areas with a soft cloth immersed in neutral detergent or ethanol.

NOTE

- Do not use solvent, such as acetone, benzene, toluene and alcohol, as these will cause the inverter surface paint to peel off.
- The display, etc. of the operation panel (FR-DU08) and parameter unit (FR-PU07) are vulnerable to detergent and alcohol. Therefore, avoid using them for cleaning.

## 5.1.6 Replacement of parts

The inverter consists of many electronic parts such as semiconductor devices.

The following parts may deteriorate with age because of their structures or physical characteristics, leading to reduced performance or fault of the inverter. For preventive maintenance, the parts must be replaced periodically.

Use the life check function as a guidance of parts replacement.

| Part name | Estimated lifespan*1 | Description |
|---|---|---|
| Cooling fan | 10 years | Replace (as required) |
| Main circuit smoothing capacitor | 10 years*2 | Replace (as required) |
| On-board smoothing capacitor | 10 years*2 | Replace the board (as required) |
| Relays | — | As required |
| Main circuit fuse | 10 years | Replace (as required) |

*1 Estimated lifespan for when the yearly average surrounding air temperature is 40°C. (without corrosive gas, flammable gas, oil mist, dust and dirt etc.)

*2 Output current (80% of the inverter rating)

NOTE

- For parts replacement, contact the nearest Mitsubishi FA center.

### ◆Inverter parts life display

The inverter diagnoses the control circuit capacitor and the cooling fan by itself, and estimates their lives.

The self-diagnostic warning is output when the life span of each part is near its end. It gives an indication of replacement time.

**The life warning output can be used as a guideline for life judgment.**

| Parts | Judgment level |
|---|---|
| Control circuit capacitor | Estimated remaining life 10% |
| Cooling fan | Approx. less than 1700 r/min |

NOTE

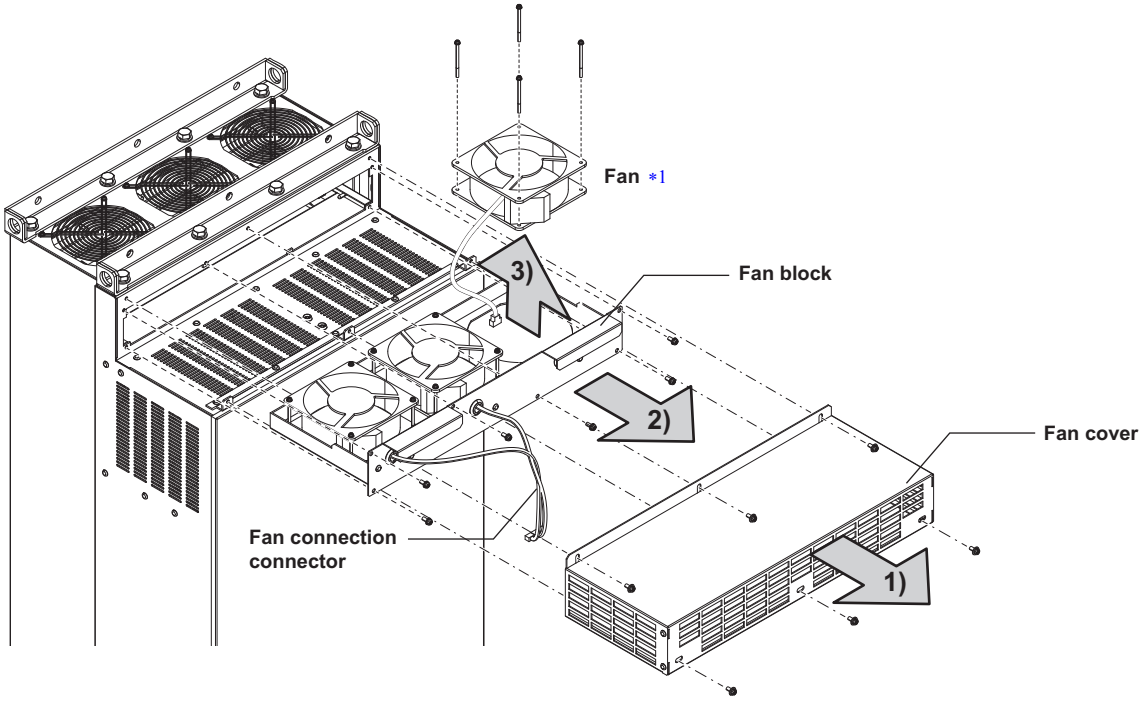
- Refer to the FR-A800 Instruction Manual (Detailed) to perform the life check of the inverter parts.

# ◆Replacement procedure of the cooling fan

The replacement interval of the cooling fan used for cooling the parts generating heat such as the main circuit semiconductor is greatly affected by the surrounding air temperature. When unusual noise and/or vibration are noticed during inspection, the cooling fan must be replaced immediately.

## ◆Removal

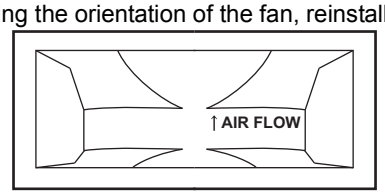
1) Remove the fan cover fixing screws, and remove the fan cover.
2) Disconnect the fan connector and remove the fan block.
3) Remove the fan fixing screws, and remove the fan.




∗1 The number of cooling fans differs according to the inverter capacity.

## ◆Reinstallation

1) After confirming the orientation of the fan, reinstall the fan so that the "AIR FLOW" faces up.




<Fan side face>

2) For reconnection of the fan, refer to the above figure.

NOTE

- Installing the fan in the opposite direction of air flow can cause the inverter life to be shorter.
- Prevent the cable from being caught when installing a fan.
- Switch the power OFF before replacing fans. Since the inverter circuits are charged with voltage even after power OFF, replace fans only when the inverter cover is on the inverter to prevent an electric shock accident.

## ◆Smoothing capacitors

A large-capacity aluminum electrolytic capacitor is used for smoothing in the main circuit DC section, and an aluminum electrolytic capacitor is used for stabilizing the control power in the control circuit. Their characteristics are deteriorated by the adverse effects of ripple currents, etc. The replacement intervals greatly vary with the surrounding air temperature and operating conditions. When the inverter is operated in air-conditioned, normal environment conditions, replace the capacitors about every 10 years.

The appearance criteria for inspection are as follows:

- Case: Check the side and bottom faces for expansion.
- Sealing plate: Check for remarkable warp and extreme crack.
- heck for external crack, discoloration, liquid leakage, etc. Judge that the capacitor has reached its life when the measured capacitance of the capacitor reduced below 80% of the rating.

NOTE

- The inverter diagnoses the control circuit capacitor by itself and can judge its life. (Refer to the FR-A800 Instruction Manual (Detailed))

## ◆Relays

To prevent a contact fault, etc., relays must be replaced according to the cumulative number of switching times (switching life).

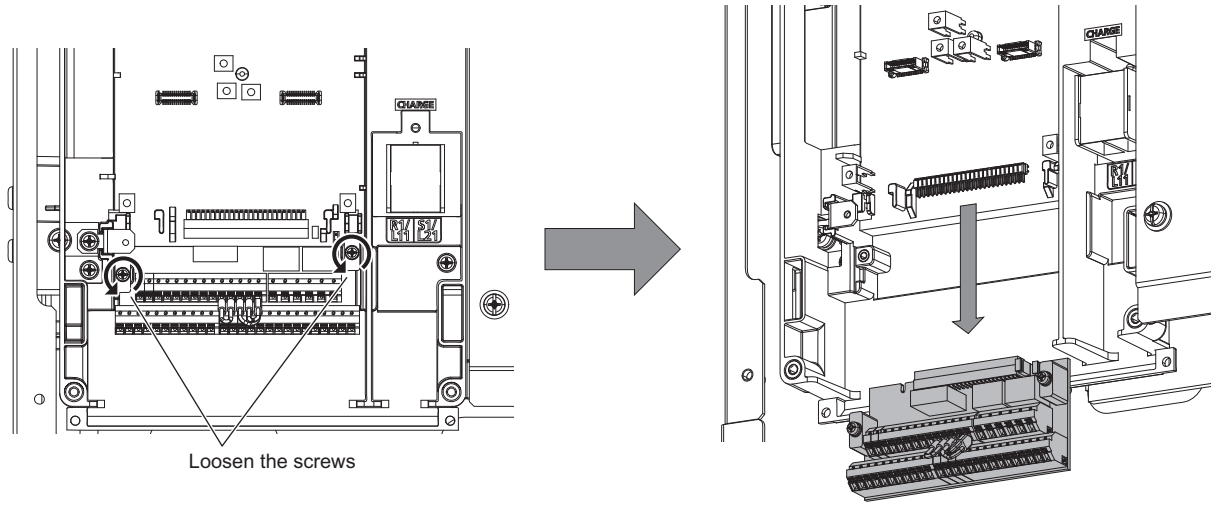
## ◆Main circuit fuse

A fuse is used inside the inverter. The replacement intervals vary with the surrounding air temperature and operating conditions. When the converter unit is operated in air-conditioned, normal environment conditions, replace the capacitors about every 10 years.

# 5.1.7 Inverter replacement

The inverter can be replaced with the control circuit wiring kept connected. Before replacement, remove the wiring cover of the inverter.

1) Loosen the two mounting screws at the both side of the control circuit terminal block. (These screws cannot be removed.) Slide down the control circuit terminal block to remove it.




2) Be careful not to bend the pins of the inverter's control circuit connector, reinstall the control circuit terminal block and fix it with the mounting screws.

NOTE

- Before starting inverter replacement, switch power OFF, wait for at least 10 minutes, and then check the voltage with a tester and such to ensure safety.

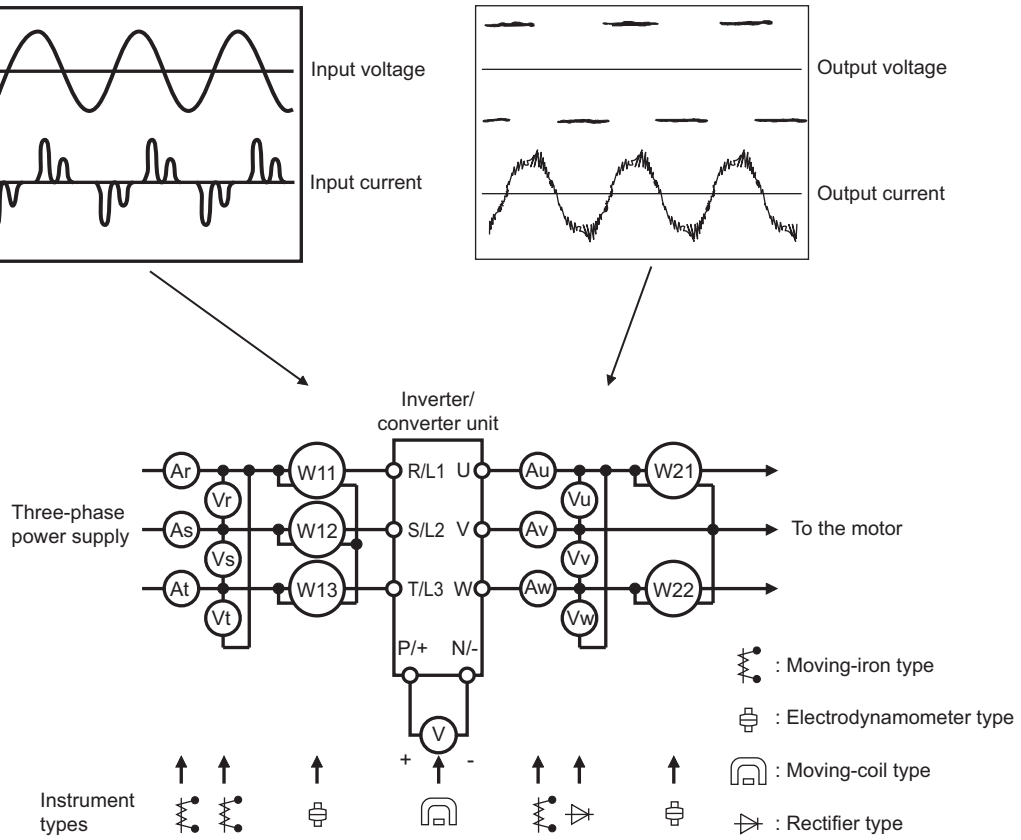
# 5.2 Measurement of main circuit voltages, currents and powers

Since the voltages and currents on the inverter power supply and output sides include harmonics, measurement data depends on the instruments used and circuits measured.
When instruments for commercial frequency are used for measurement, measure the following circuits with the instruments given on the next page.

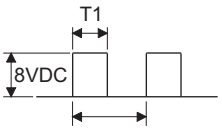
NOTE

- When installing meters etc. on the inverter output side
  When the wiring length between the inverter and the motor is large, the meters and CTs may generate heat due to line-to-line leakage current. Therefore, choose the equipment which has enough allowance for the current rating.
  To measure and display the output voltage and output current of the inverter, it is recommended to use the terminal AM and FM/CA output functions of the inverter.

## ◆Examples of measuring points and instruments



## ◆Measuring points and instruments

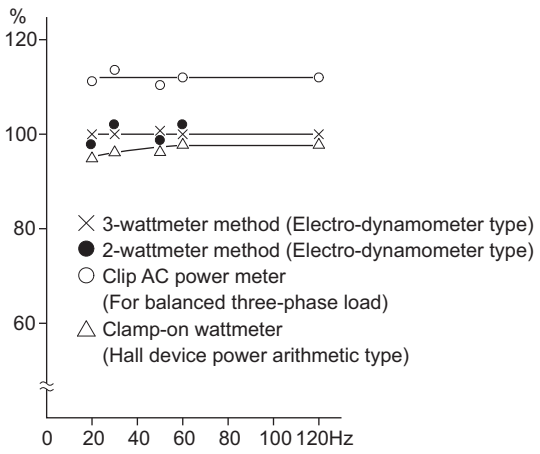
| | Item | Measuring point | Measuring instrument | Remarks (reference measured value) | |
|---|---|---|---|---|---|
| Converter unit (FR-CC2) | Power supply voltage<br>V1 | Across R/L1 and S/L2, S/L2 and T/L3, T/L3 and R/L1 | Moving-iron type AC voltmeter*4 | Commercial power supply<br>Within permissible AC voltage fluctuation (Refer to page 98.) | |
| | Power supply side current<br>I1 | R/L1, S/L2, T/L3 line current | Moving-iron type AC ammeter*4 | | |
| | Power supply side power<br>P1 | R/L1, S/L2, T/L3 and Across R/L1 and S/L2, S/L2 and T/L3, T/L3 and R/L1 | Digital power meter (for inverter) or electrodynamic type single-phase wattmeter | P1 = W11 + W12 + W13 (3-wattmeter method) | |
| | Power supply side power factor<br>Pf1 | Calculate after measuring power supply voltage, power supply side current and power supply side power.<br>$Pf_1 = \frac{P_1}{\sqrt{3}V_1 \times I_1} \times 100\%$ | | | |
| | Converter output | Across P/+ and N/- | Moving-coil type (such as tester) | Inverter LED is lit. 1.35 × V1 | |
| | Operation enable signal<br>External thermal relay signal<br>Reset signal | Across RDI, OH, RES(+) and SD (for sink logic) | Moving-coil type (tester and such may be used.) (internal resistance 50 kΩ or more) | When open<br>20 to 30 VDC<br>ON voltage: 1 V or less | "SD" is common |
| | Alarm signal | Across A1 and C1<br>Across B1 and C1 | Moving-coil type (such as tester) | Continuity check*3<br>[Normal] / [Fault]<br>Across A1 and C1: Discontinuity / Continuity<br>Across B1 and C1: Continuity / Discontinuity | |
| Inverter | Output side voltage<br>V2 | Across U and V, V and W, and W and U | Rectifier type AC voltage meter*1*4 (moving-iron type cannot measure.) | Difference between the phases is within 1% of the maximum output voltage. | |
| | Output side current<br>I2 | U, V and W line currents | Moving-iron type AC ammeter*2*4 | Difference between the phases is 10% or lower of the rated inverter current. | |
| | Output side power<br>P2 | U, V, W and across U and V, V and W | Digital power meter (for inverter) or electrodynamic type single-phase wattmeter | P2 = W21 + W22<br>2-wattmeter method (or 3-wattmeter method) | |
| | Output side power factor<br>Pf2 | Calculate in similar manner to power supply side power factor.<br>$Pf_2 = \frac{P_2}{\sqrt{3}V_2 \times I_2} \times 100\%$ | | | |
| | Frequency setting signal | Across 2, 4(+) and 5 | Moving-coil type (tester and such may be used.) (internal resistance 50 kΩ or more) | 0 to 10 VDC, 4 to 20 mA | "5" is common |
| | | Across 1(+) and 5 | | 0 to ±5 VDC and 0 to ±10 VDC | |
| | Frequency setting power supply | Across 10(+) and 5 | | 5.2 VDC | |
| | | Across 10E(+) and 5 | | 10 VDC | |
| | Frequency meter signal | Across AM(+) and 5 | | Approximately 10 VDC at maximum frequency<br>(without frequency meter) | |
| | | Across CA(+) and 5 | | Approximately 20 mADC at maximum frequency | |
| | | Across FM(+) and SD | | Approximately 5 VDC at maximum frequency<br>(without frequency meter)<br>  <br><br>Pulse width T1: Adjust with **C0 (Pr.900)**.<br>Pulse cycle T2: Set with **Pr.55**.<br>(frequency monitor only) | "SD" is common |
| | Start signal<br>Select signal<br>Reset signal<br>Output stop signal | Across STF, STR, RH, RM, RL, JOG, RT, AU, STOP, CS, RES, MRS(+) and SD (for sink logic) | | When open<br>20 to 30 VDC<br>ON voltage: 1 V or less | |
| | Fault signal | Across A1 and C1<br>Across B1 and C1 | Moving-coil type (such as tester) | Continuity check*3<br>[Normal] / [Fault]<br>Across A1 and C1: Discontinuity / Continuity<br>Across B1 and C1: Continuity / Discontinuity | |

∗1 Use an FFT to measure the output voltage accurately. A tester or general measuring instrument cannot measure accurately.
∗2 When the carrier frequency exceeds 5 kHz, do not use this instrument since using it may increase eddy current losses produced in metal parts inside the instrument, leading to burnout. In this case, use an approximate-effective value type.
∗3 When the setting of **Pr.195 ABC1 terminal function selection** is the positive logic
∗4 A digital power meter (designed for inverter) can also be used to measure.

# 5.2.1 Measurement of powers

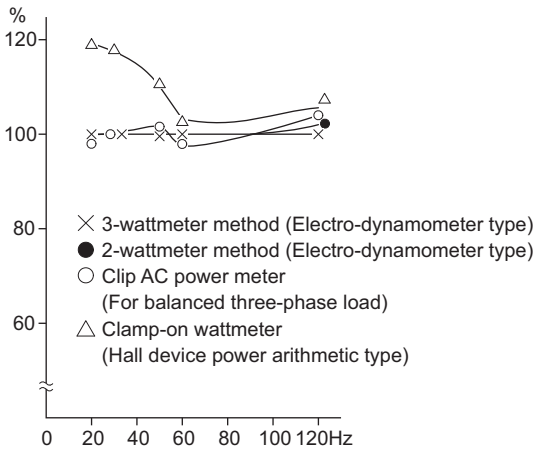
Use a digital power meter (for inverter) for the input side of the converter unit (FR-CC2) and the output side of the inverter. Alternatively, measure using electrodynamic type single-phase wattmeters for the input side of the converter unit and output side of the inverter in two-wattmeter or three-wattmeter method. As the current is liable to be imbalanced especially in the input side, it is recommended to use the three-wattmeter method.
Examples of measured value differences produced by different measuring meters are shown below.
An error will be produced by difference between measuring instruments, e.g. power calculation type and two- or three-wattmeter type three-phase wattmeter. When a CT is used in the current measuring side or when the meter contains a PT on the voltage measurement side, an error will also be produced due to the frequency characteristics of the CT and PT.

[Measurement conditions]
Constant output of 60 Hz or more frequency with a constant-torque (100%). The value obtained by the 3-wattmeter method with a 4-pole 3.7 kW induction motor is assumed to be 100%.




**Example of measuring inverter input power**

[Measurement conditions]
Constant output of 60 Hz or more frequency with a constant-torque (100%). The value obtained by the 3-wattmeter method with a 4-pole 3.7 kW induction motor is assumed to be 100%.




**Example of measuring inverter output power**

# 5.2.2 Measurement of voltages and use of PT

## ◆Converter unit (FR-CC2) input side

As the input side voltage has a sine wave and it is extremely small in distortion, accurate measurement can be made with an ordinary AC meter.

## ◆Inverter output side

Since the output side voltage has a PWM-controlled rectangular wave, always use a rectifier type voltmeter. A needle type tester cannot be used to measure the output side voltage as it indicates a value much greater than the actual value. A moving-iron type meter indicates an effective value which includes harmonics and therefore the value is larger than that of the fundamental wave. The value monitored on the operation panel is the inverter-controlled voltage itself. Hence, that value is accurate and it is recommended to monitor values (analog output) using the operation panel.

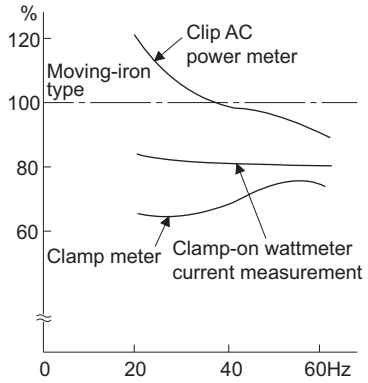
## ◆PT

No PT can be used in the output side of the inverter. Use a direct-reading meter. (A PT can be used in the input side of the converter unit (FR-CC2).)

## 5.2.3 Measurement of currents

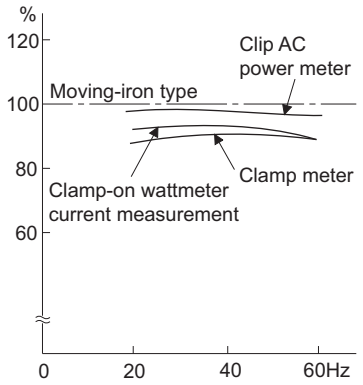
Use moving-iron type meter on the input side of the converter unit (FR-CC2) and the output side of the inverter. However, if the carrier frequency exceeds 5 kHz, do not use that meter since an overcurrent losses produced in the internal metal parts of the meter will increase and the meter may burn out. In this case, use an approximate-effective value type.
Since current on the converter unit input side tends to be unbalanced, measurement of three phases is recommended. Correct value cannot be obtained by measuring only one or two phases. On the other hand, the unbalanced ratio of each phase of the output side current should be within 10%.
When a clamp ammeter is used, always use an effective value detection type. A mean value detection type produces a large error and may indicate an extremely smaller value than the actual value. The value monitored on the operation panel is accurate if the output frequency varies, and it is recommended to monitor values (provide analog output) using the operation panel.
Examples of measured value differences produced by different measuring meters are shown below.

[Measurement conditions]
Indicated value of the moving-iron type ammeter is 100%.




**Example of measuring converter unit input current**

[Measurement conditions]
Indicated value of the moving-iron type ammeter is 100%.




**Example of measuring inverter output current**

## 5.2.4 Use of CT and transducer

A CT may be used in both the input side of the converter unit and the output side of the inverter. Use the one with the largest possible VA ability because an error will increase if the frequency gets lower.
When using a transducer, use the effective value calculation type which is immune to harmonics.

## 5.2.5 Example of measuring converter unit (FR-CC2) input power factor

Calculate using effective power and apparent power. A power-factor meter cannot indicate an exact value.

$$\text{Total power factor of the converter unit} = \frac{\text{Effective power}}{\text{Apparent power}} = \frac{\text{Three-phase input power found by the 3-wattmeter method}}{\sqrt{3} \times \text{V (power supply voltage)} \times \text{I (input current effective value)}}$$

## 5.2.6 Measurement of converter output voltage (across terminals P and N)

The output voltage of the converter is output across terminals P and N and can be measured with a moving-coil type meter (tester). Although the voltage varies according to the power supply voltage, approximately 540 to 600 V is output when no load is connected and voltage decreases during driving load operation.
When energy is regenerated from the motor during deceleration, for example, the converter output voltage rises to nearly 800 to 900 V maximum.

## 5.2.7 Measurement of inverter output frequency

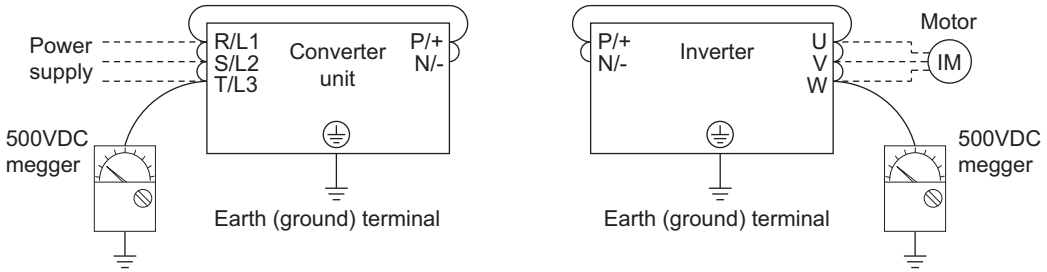
In the initial setting of the FM-type inverter, a pulse train proportional to the output frequency is output across the pulse train output terminals FM and SD of the inverter. This pulse train output can be counted by a frequency counter, or a meter (moving-coil type voltmeter) can be used to read the mean value of the pulse train output voltage. When a meter is used to measure the output frequency, approximately 5 VDC is indicated at the maximum frequency.
For detailed specifications of the pulse train output terminal FM, refer to the FR-A800 Instruction Manual (Detailed).
In the initial setting of the CA-type inverter, a pulse train proportional to the output frequency is output across the analog current output terminals CA and 5 of the inverter. Measure the current using an ammeter or tester.
For detailed specifications of the analog current output terminal CA, refer to the FR-A800 Instruction Manual (Detailed).

## 5.2.8 Insulation resistance test using megger

- For the inverter and the converter unit (FR-CC2), conduct the insulation resistance test on the main circuit only as shown below and do not perform the test on the control circuit. (Use a 500 VDC megger.)

NOTE

- Before performing the insulation resistance test on the external circuit, disconnect the cables from all terminals of the inverter and the converter unit so that the test voltage is not applied to the inverter and the converter unit.
- For the continuity test of the control circuit, use a tester (high resistance range) and do not use the megger or buzzer.




## 5.2.9 Pressure test

Do not conduct a pressure test. Deterioration may occur.

# 6 SPECIFICATIONS

This chapter explains the "SPECIFICATIONS" of this product.
Always read the instructions before using the equipment.


**6.1 Inverter rating ..... 98**
**6.2 Common specifications ..... 100**
**6.3 Outline dimension drawings ..... 102**

# 6.1 Inverter rating

## ◆ 400 V class

• Inverter

| Model FR-A842-[ ] | | | 315K | 355K | 400K | 450K | 500K |
|---|---|---|---|---|---|---|---|
| | | | 07700 | 08660 | 09620 | 10940 | 12120 |
| Applicable motor capacity (kW) *1 | | SLD | 400 | 450 | 500 | — | — |
| | | LD | 355 | 400 | 450 | 500 | — |
| | | ND (initial setting) | 315 | 355 | 400 | 450 | 500 |
| | | HD | 280 | 315 | 355 | 400 | 450 |
| Output | Rated capacity (kVA) *2 | SLD | 587 | 660 | 733 | 834 | 924 |
| | | LD | 521 | 587 | 660 | 733 | 834 |
| | | ND (initial setting) | 465 | 521 | 587 | 660 | 733 |
| | | HD | 417 | 465 | 521 | 587 | 660 |
| | Rated current (A) | SLD | 770 | 866 | 962 | 1094 | 1212 |
| | | LD | 683 | 770 | 866 | 962 | 1094 |
| | | ND (initial setting) | 610 | 683 | 770 | 866 | 962 |
| | | HD | 547 | 610 | 683 | 770 | 866 |
| | Overload current rating *3 | SLD | 110% 60 s, 120% 3 s (inverse-time characteristics) at surrounding air temperature 40°C | | | | |
| | | LD | 120% 60 s, 150% 3 s (inverse-time characteristics) at surrounding air temperature 50°C | | | | |
| | | ND (initial setting) | 150% 60 s, 200% 3 s (inverse-time characteristics) at surrounding air temperature 50°C | | | | |
| | | HD | 200% 60 s, 250% 3 s (inverse-time characteristics) at surrounding air temperature 50°C | | | | |
| | Rated voltage *4 | | Three-phase 380 to 500 V | | | | |
| | Regenerative brakingtorque*5 (When the converter unit (FR-CC2) is used) | Maximum brake torque | 10% torque/continuous | | | | |
| Input power | DC power supply voltage | | 430 to 780 VDC | | | | |
| | Control power supply auxiliary input | | Single phase 380 to 500 V 50 Hz/60 Hz *7 | | | | |
| | Permissible control power supply auxiliary input fluctuation | | Frequency ±5%, voltage ±10% | | | | |
| Protective structure (IEC 60529) *6 | | | Open type (IP00) | | | | |
| Cooling system | | | Forced air cooling | | | | |
| Approx. mass (kg) | | | 163 | 163 | 243 | 243 | 243 |

*1 The applicable motor capacity indicated is the maximum capacity applicable for use of the Mitsubishi 4-pole standard motor.

*2 The rated output capacity indicated assumes that the output voltage is 440 V.

*3 The % value of the overload current rating indicated is the ratio of the overload current to the inverter's rated output current. For repeated duty, allow time for the inverter and motor to return to or below the temperatures under 100% load.

*4 The maximum output voltage does not exceed the power supply voltage. The maximum output voltage can be changed within the setting range. However, the maximum point of the voltage waveform at the inverter output side is the power supply voltage multiplied by about $\sqrt{2}$.

*5 ND rating reference value

*6 FR-DU08: IP40 (except for the PU connector section)

*7 For the power voltage exceeding 480 V, set **Pr.977 Input voltage mode selection**. (For details, refer to the FR-A800 Instruction Manual (Detailed).)

• Converter unit (FR-CC2)

| Model FR-CC2-H[ ] | | 315K | 355K | 400K | 450K | 500K |
|---|---|---|---|---|---|---|
| Applicable motor capacity (kW) | | 315 | 355 | 400 | 450 | 500 |
| Output | Overload current rating *1 | 150% 60 s, 200% 3 s | | | | |
| | Rated voltage *2 | 430 to 780 VDC *5 | | | | |
| Power supply | Rated input AC voltage/frequency | Three-phase 380 to 500 V 50 Hz/60 Hz | | | | |
| | Permissible AC voltage fluctuation | Three-phase 323 to 550 V 50 Hz/60 Hz | | | | |
| | Permissible frequency fluctuation | ±5% | | | | |
| | Rated input current (A) | 610 | 683 | 770 | 866 | 962 |
| | Power supply capacity (kVA) *3 | 465 | 521 | 587 | 660 | 733 |
| Protective structure (IEC 60529) *4 | | Open type (IP00) | | | | |
| Cooling system | | Forced air cooling | | | | |
| DC reactor | | Built-in | | | | |
| Approx. mass (kg) | | 210 | 213 | 282 | 285 | 288 |

*1 The % value of the overload current rating indicated is the ratio of the overload current to the inverter's rated output current. For repeated duty, allow time for the converter unit and the inverter to return to or below the temperatures under 100% load.

*2 The converter unit output voltage varies according to the input power supply voltage and the load. The maximum point of the voltage waveform at the converter unit output side is approximately the power supply voltage multiplied by $\sqrt{2}$.

*3 The power supply capacity is the value when at the rated output current. It varies by the impedance at the power supply side (including those of the input reactor and cables).

*4 FR-DU08: IP40 (except for the PU connector section)

*5 The permissible voltage imbalance ratio is 3% or less. (Imbalance ratio = (highest voltage between lines - average voltage between three lines ) / average voltage between three lines × 100)

# 6.2 Common specifications

| | | | |
|---|---|---|---|
| Control specifications | Control method | | Soft-PWM control, high carrier frequency PWM control (selectable among V/F control, Advanced magnetic flux vector control, Real sensorless vector control), Optimum excitation control, vector control*1, and PM sensorless vector control |
| | Output frequency range | | 0.2 to 590 Hz (The upper-limit frequency is 400 Hz under Advanced magnetic flux vector control, Real sensorless vector control, vector control*1, and PM sensorless vector control.) |
| | Frequency setting resolution | Analog input | 0.015 Hz/60 Hz (terminal 2, 4: 0 to 10 V/12 bits)<br>0.03 Hz/60 Hz (0 to 5 V/11 bits or 0 to 20 mA/approx. 11 bits for terminals 2 and 4, 0 to ±10 V/12 bits for terminal 1)<br>0.06 Hz/60 Hz (0 to ±5 V/11 bits for terminal 1) |
| | | Digital input | 0.01 Hz |
| | Frequency accuracy | Analog input | Within ±0.2% of the max. output frequency (25°C ±10°C) |
| | | Digital input | Within 0.01% of the set output frequency |
| | Voltage/frequency characteristics | | Base frequency can be set from 0 to 590 Hz. Constant-torque/variable-torque pattern or adjustable 5 points V/F can be selected. |
| | Starting torque | | SLD rating: 120% 0.3 Hz, LD rating: 150% 0.3 Hz, ND rating: 200%*2 0.3 Hz, HD rating: 250%*2 0.3 Hz<br>(under Real sensorless vector control or vector control*1) |
| | Torque boost | | Manual torque boost |
| | Acceleration/deceleration time setting | | 0 to 3600 s (acceleration and deceleration can be set individually), linear or S-pattern acceleration/deceleration mode, backlash countermeasures acceleration/deceleration can be selected. |
| | DC injection brake (induction motor) | | Operation frequency (0 to 120 Hz), operation time (0 to 10 s), operation voltage (0 to 30%) variable |
| | Stall prevention operation level | | Activation range of stall prevention operation (SLD rating: 0 to 120%, LD rating: 0 to 150%, ND rating: 0 to 220%, HD rating: 0 to 280%). Whether to use the stall prevention or not can be selected. (V/F control, Advanced magnetic flux vector control) |
| | Torque limit level | | Torque limit value can be set (0 to 400% variable). (Real sensorless vector control, vector control*1, PM sensorless vector control) |
| Operation specifications | Frequency setting signal | Analog input | Terminals 2 and 4: 0 to 10 V, 0 to 5 V, 4 to 20 mA (0 to 20 mA) are available.<br>Terminal 1: -10 to +10 V, -5 to 5 V are available. |
| | | Digital input | Input using the setting dial of the operation panel or parameter unit<br>Four-digit BCD or 16-bit binary (when used with option FR-A8AX) |
| | Start signal | | Forward and reverse rotation or start signal automatic self-holding input (3-wire input) can be selected. |
| | Input signals (twelve terminals) | | Low-speed operation command, Middle-speed operation command, High-speed operation command, Second function selection, Terminal 4 input selection, Jog operation selection, Selection of automatic restart after instantaneous power failure, flying start, Output stop, Start self-holding selection, Forward rotation command, Reverse rotation command, Inverter reset<br>The input signal can be changed using **Pr.178 to Pr.189 (input terminal function selection)**. |
| | Pulse train input | | 100 kpps |
| | Operational functions | | Maximum and minimum frequency settings, multi-speed operation, acceleration/deceleration pattern, thermal protection, DC injection brake, starting frequency, JOG operation, output stop (MRS), stall prevention, regeneration avoidance, increased magnetic excitation deceleration, frequency jump, rotation display, automatic restart after instantaneous power failure, electronic bypass sequence, remote setting, automatic acceleration/deceleration, intelligent mode, retry function, carrier frequency selection, fast-response current limit, forward/reverse rotation prevention, operation mode selection, slip compensation, droop control, load torque high-speed frequency control, speed smoothing control, traverse, auto tuning, applied motor selection, gain tuning, RS-485 communication, PID control, PID pre-charge function, easy dancer control, cooling fan operation selection, stop selection (deceleration stop/coasting), stop-on-contact control, PLC function, life diagnosis, maintenance timer, current average monitor, multiple rating, orientation control*1, speed control, torque control, position control, pre-excitation, torque limit, test run, 24 V power supply input for control circuit, safety stop function, vibration control |
| | Output signal<br>Open collector output (five terminals)<br>Relay output (two terminals) | | Inverter running, Up to frequency, Overload warning, Output frequency detection, Fault<br>The output signal can be changed using **Pr.190 to Pr.196 (output terminal function selection)**.<br>Fault codes of the inverter can be output (4 bits) from the open collector. |
| | Pulse train output | | 50 kpps |
| Indication | For meter | Pulse train output (FM type) | Max. 2.4 kHz: one terminal (output frequency)<br>The monitored item can be changed using **Pr.54 FM/CA terminal function selection**. |
| | | Current output (CA type) | Max. 20 mADC: one terminal (output current)<br>The monitored item can be changed using **Pr.54 FM/CA terminal function selection**. |
| | | Voltage output | Max. 10 VDC: one terminal (output voltage)<br>The monitored item can be changed using **Pr.158 AM terminal function selection**. |
| | Operation panel (FR-DU08) | Operating status | Output frequency, output current, output voltage, frequency setting value<br>The monitored item can be changed using **Pr.52 Operation panel main monitor selection**. |
| | | Fault record | Fault record is displayed when a fault occurs. Past 8 fault records and the conditions immediately before the fault (output voltage/current/frequency/cumulative energization time/year/month/date/time) are saved. |

| | | |
|---|---|---|
| **Protective/ warning function** | **Protective function** | Overcurrent trip during acceleration, Overcurrent trip during constant speed, Overcurrent trip during deceleration or stop, Regenerative overvoltage trip during acceleration, Regenerative overvoltage trip during constant speed, Regenerative overvoltage trip during deceleration or stop, Inverter overload trip (electronic thermal relay function), Motor overload trip (electronic thermal relay function), Heatsink overheat, Stall prevention stop, Loss of synchronism detection*5, Output side earth (ground) fault overcurrent, Output phase loss, External thermal relay operation*5, PTC thermistor operation*5, Option fault, Communication option fault, Parameter storage device fault, PU disconnection, Retry count excess*5, Parameter storage device fault, CPU fault, Operation panel power supply short circuit/RS-485 terminals power supply short circuit, 24 VDC power fault, Abnormal output current detection*5, Communication fault (inverter), Analog input fault, USB communication fault, Safety circuit fault, Overspeed occurrence*5, Speed deviation excess detection*1*5, Signal loss detection*1*5, Excessive position fault*1*5, Brake sequence fault*5, Encoder phase fault*1*5, 4 mA input fault*5, Pre-charge fault*5, PID signal fault*5, Option fault, Opposite rotation deceleration fault*5, Internal circuit fault |
| | **Warning function** | Fan alarm, Stall prevention (overcurrent), Stall prevention (overvoltage), Electronic thermal relay function pre-alarm, PU stop, Speed limit indication (output during speed limit)*5, Parameter copy, Safety stop, Maintenance timer 1 to 3*5, USB host error, Home position return setting error*5, Home position return uncompleted*5, Home position return parameter setting error*5, Operation panel lock*5, Password locked*5, Parameter write error, Copy operation error, 24 V external power supply operation |
| **Environment** | **Surrounding air temperature** | -10°C to +50°C (non-freezing) (LD, ND, HD ratings)<br>-10°C to +40°C (non-freezing) (SLD rating) |
| | **Surrounding air humidity** | With circuit board coating: 95% RH or less (non-condensing)<br>Without circuit board coating: 90% RH or less (non-condensing) |
| | **Storage temperature*3** | -20°C to +65°C |
| | **Atmosphere** | Indoors (without corrosive gas, flammable gas, oil mist, dust and dirt, etc.) |
| | **Altitude/vibration** | Maximum 1000 m above sea level, 2.9 m/s$^2$ or less*4 at 10 to 55 Hz (directions of X, Y, Z axes) |

*1 Available only when the option (FR-A8AP) is mounted.

*2 In the initial setting, it is limited to 150% by the torque limit level.

*3 Temperature applicable for a short time, e.g. in transit.

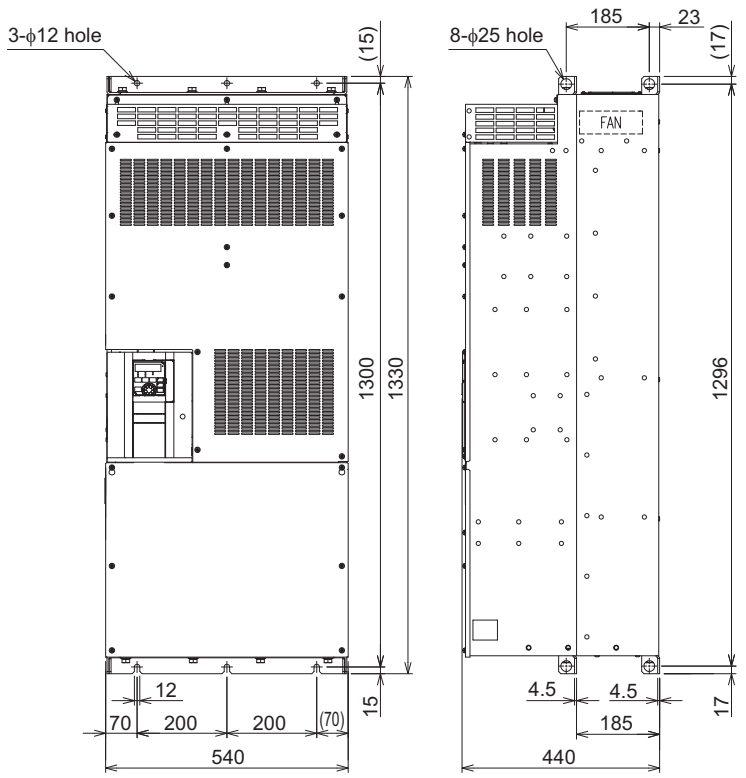
*4 For the installation in an altitude above 1,000 m (up to 2,500 m), derate the rated current 3% per 500 m.

*5 This protective function is not available in the initial status.

# 6.3 Outline dimension drawings

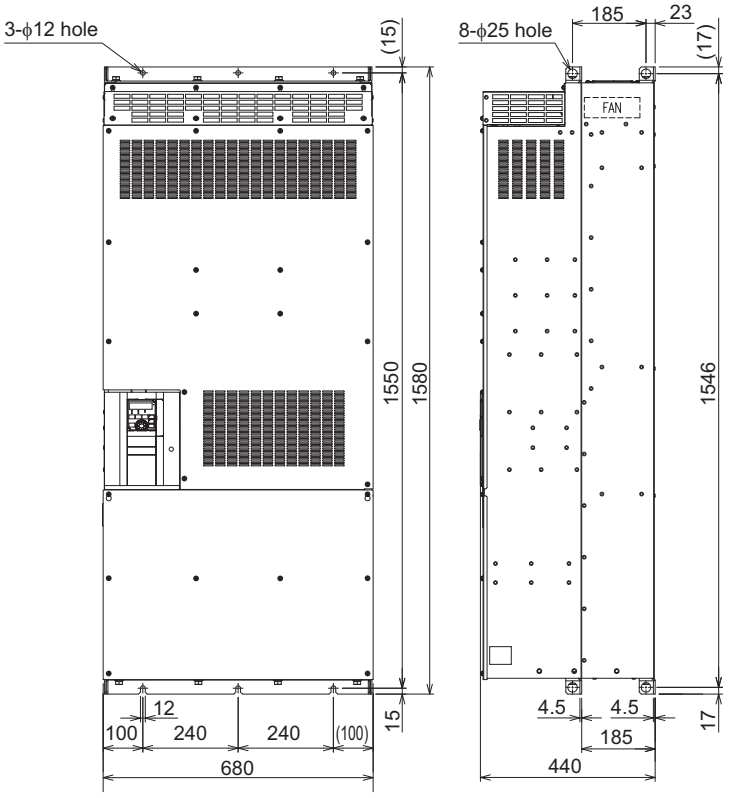
## 6.3.1 Inverter outline dimension drawings

FR-A842-07700(315K), FR-A842-08660(355K)




(Unit: mm)

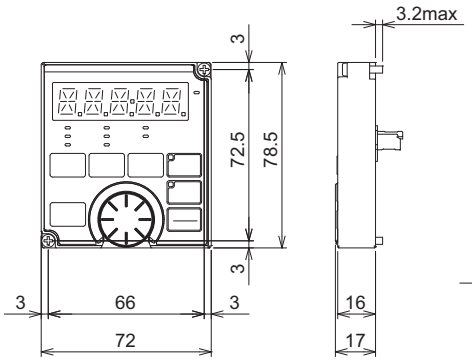
FR-A842-09620(400K), FR-A842-10940(450K), FR-A842-12120(500K)



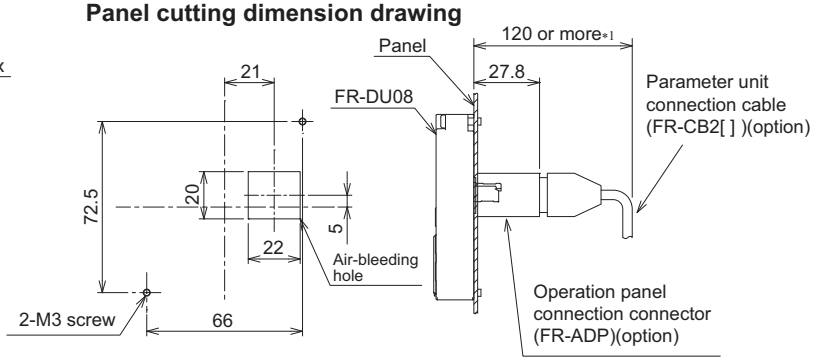

(Unit: mm)

Operation panel (FR-DU08)

**Outline drawing**




**Panel cutting dimension drawing**

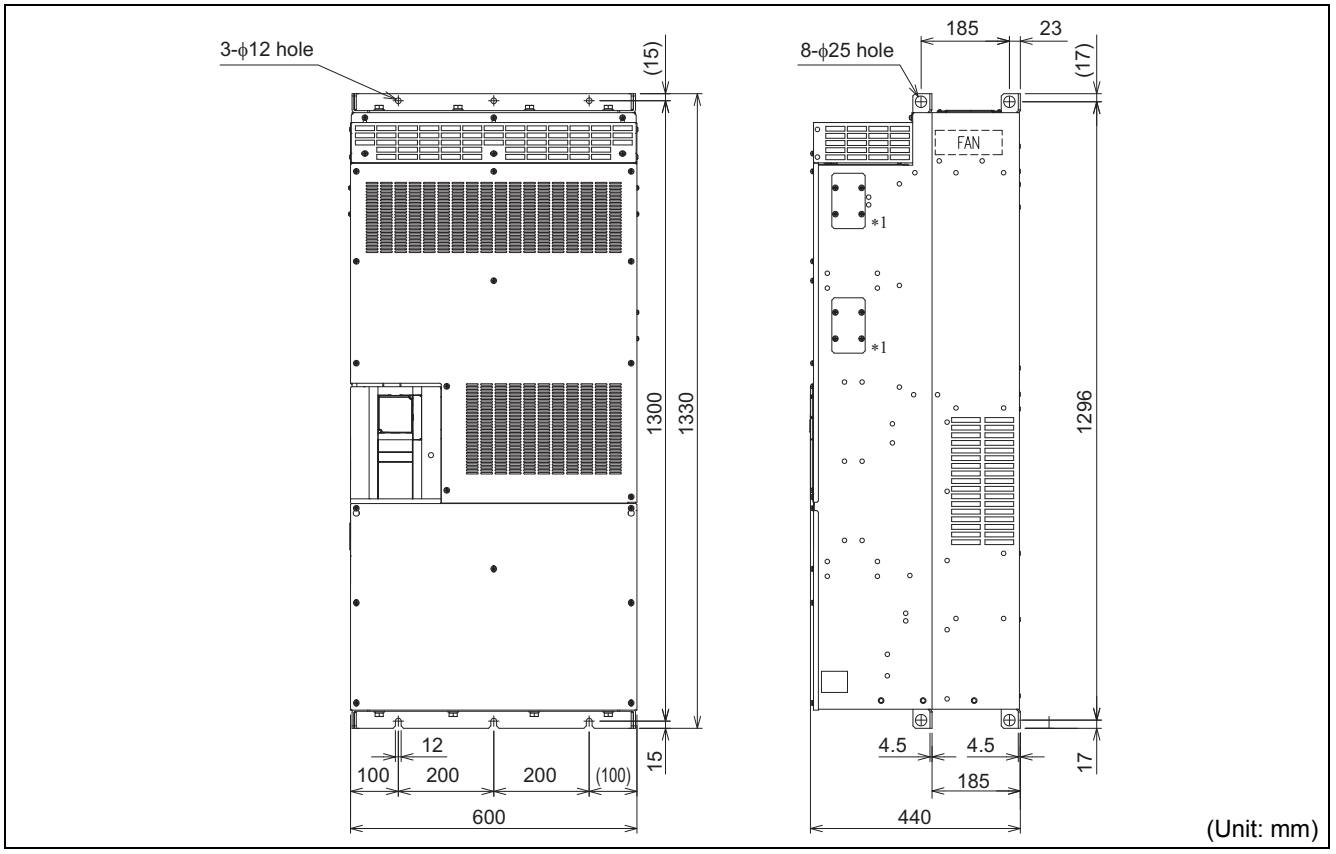



*1 Denotes the space required to connect an optional parameter unit connection cable (FR-CB2[ ]). When using another cable, leave the space required for the cable specification.

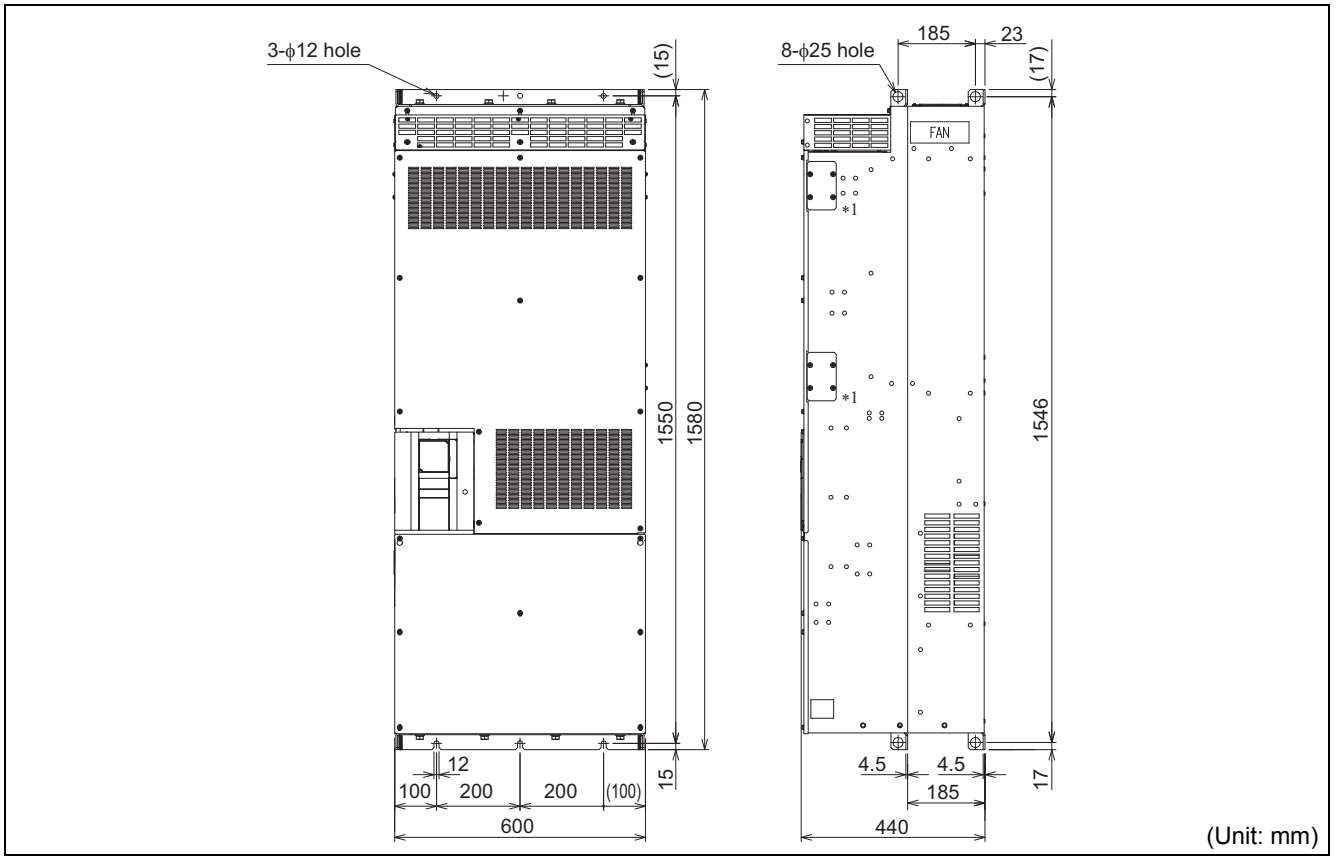
(Unit: mm)

# 6.3.2 Converter unit (FR-CC2) outline dimension drawings

FR-CC2-H315K, FR-CC2-H355K




FR-CC2-H400K, FR-CC2-H450K, FR-CC2-H500K




*1 Do not remove the cover on the side of the converter unit.

# APPENDIX

**APPENDIX provides the reference information for use of this product.**
**Refer to APPENDIX as required.**


**Appendix1 For customers replacing the conventional model with this inverter .....106**
**Appendix2 Comparison with FR-A840.....108**
**Appendix3 Instructions for compliance with the EU Directives ..109**
**Appendix4 Instructions for UL and cUL.....111**

# Appendix1 For customers replacing the conventional model with this inverter

## Appendix1.1 Replacement of the FR-A740 series

### ◆Difference and compatibility with FR-A740 series

| Item | | FR-A740 | FR-A842 |
|---|---|---|---|
| **Control method** | | V/F control<br>Advanced magnetic flux vector control<br>Real sensorless vector control<br>Vector control (with plug-in option used)<br>PM sensorless vector control (IPM motor) | V/F control<br>Advanced magnetic flux vector control<br>Real sensorless vector control<br>Vector control (with plug-in option used)<br>PM sensorless vector control (IPM motor/SPM motor) |
| **Added functions** | | - | USB host function<br>Safety stop function<br>etc. |
| **Maximum output frequency** | **V/F control** | 400 Hz | 590 Hz |
| | **Advanced magnetic flux vector control** | 120 Hz | 400 Hz |
| | **Real sensorless vector control** | 120 Hz | 400 Hz |
| | **Vector control** | 120 Hz | 400 Hz |
| | **PM sensorless vector control (MM-CF)** | 300 Hz | 400 Hz |
| **PID control** | | Turn the X14 signal ON to enable PID control. | The X14 signal does not need to be assigned. (PID control is available by the **Pr.128** setting.)<br>The PID pre-charge function and dancer control are added. |
| **Automatic restart after instantaneous power failure** | | Turn the CS signal ON to restart. | CS signal assignment not required. (Restart is enabled with the **Pr.57** setting only.) |
| **Number of motor poles V/F control switching** | | The V/F switchover (X18) signal is valid when **Pr.81** = "12 to 20 (2 to 10 poles)". | **Pr.81**= "12 (12 poles)"<br>X18 is valid regardless of the **Pr.81** setting. (The **Pr.81** settings "14 to 20" are not available.) |
| PTC thermistor input | | Input from the terminal AU<br>(The function of the terminal AU is switched by a switch.) | Input from the terminal 2.<br>(The function of the terminal 2 is switched by the **Pr.561** setting.) |
| USB connector | | B connector | Mini B connector |
| Control circuit terminal block | | Removable terminal block (screw type) | Removable terminal block (spring clamp type) |
| Terminal response level | | The FR-A800's I/O terminals have better response level than the FR-A700's terminals. By setting **Pr.289 Inverter output terminal filter** and **Pr.699 Input terminal filter**, the terminal response level can be compatible with that of FR-A700. Set to approximately 5 to 8 ms and adjust the setting according to the system. | |
| PU | | FR-DU07 (4-digit LED)<br>FR-PU07 | FR-DU08 (5-digit LED)<br>FR-PU07 (Some functions, such as parameter copy, are unavailable.)<br>FR-DU07 is not supported. |
| Plug-in option | | Dedicated plug-in options (not interchangeable) | |
| Communication option | | Connected to the connector 3. | Connected to the connector 1. |
| Installation size | | Installation size is not compatible. (New mounting holes are required.) | |
| Converter | | Built in for all capacities | The converter unit (FR-CC2) is required. |
| DC reactor | | DC reactor (FR-HEL) is provided. | Built in the converter unit (FR-CC2) |

### ◆Installation precautions

- Removal procedure of the front cover is different. (Refer to page 15.)
- Plug-in options of the FR-A700 series are not compatible.
- Operation panel (FR-DU07) cannot be used.

## ◆Wiring precautions

- The spring clamp type terminal block has changed to the screw type. Use of blade terminals is recommended.

## ◆Instructions for continuous use of the FR-PU07 (parameter unit)

- For the FR-A800 series, many functions (parameters) have been added. When setting these parameters, the parameter names and setting ranges are not displayed.
- Only the parameter with the numbers up to "999" can be read and set. The parameters with the numbers after "999" cannot be read or set.
- Many protective functions have been added for the FR-A800 series. These functions are available, but all faults are displayed as "Fault". When the faults history is checked, "ERR" appears. Added faults will not appear on the parameter unit. (However, MT1 to MT3 are displayed as MT.)
- Parameter copy/verification function are not available.

## ◆Copying parameter settings

- The FR-A700 series' parameter setting can be easily copied to the FR-A800 series by using the setup software (FR Configurator2). (Not supported by the the setup software FR-SW3-SETUP or older.)

# Appendix1.2 Replacement of the FR-A500(L) series

## ◆Installation precautions

- Installation size is not compatible. (New mounting holes are required.)
- The optional converter unit (FR-CC2) is required.

# Appendix2 Comparison with FR-A840

| Item | FR-A840 | FR-A842 |
|---|---|---|
| **Power failure time deceleration-to-stop function (Pr.261 to Pr.266, Pr.294, Pr.668)** | With the parameter | Without the parameter |
| **Pr.30 Regenerative function selection** | Setting ranges "0 to 2, 10, 11, 20, 21, 100, 101, 110, 111, 120, 121"<br>Initial value "0" | Setting ranges "2, 10, 11, 102, 110, 111"<br>Initial value "10" |
| **Pr.70 Special regenerative brake duty** | With the parameter | Without the parameter |
| **Monitor function (Pr.52, Pr.54, Pr.158, Pr.774 to Pr.776, Pr.992, Pr.1027 to Pr.1034)** | Regenerative brake duty<br>With (Acceptable) | Regenerative brake duty<br>Without (Unacceptable) |
| **Input terminal function selection (Pr.178 to Pr.189)** | DC feeding operation permission (X70), DC feeding cancel (X71)<br>With (Acceptable) | DC feeding operation permission (X70), DC feeding cancel (X71)<br>Without (Unacceptable) |
| **Pr.187 MRS terminal function selection** | Initial value "24" (MRS) | Initial value "10" (X10) |
| **Output terminal function assignment selection (Pr.190 to Pr.196, Pr.313 to Pr.322)** | Instantaneous power failure/undervoltage (IPF), During deceleration at occurrence of power failure (retained until release) (Y46), Regenerative brake pre-alarm (RBP), DC current feeding (Y85), Main circuit capacitor life (Y87), Inrush current limit circuit life (Y89)<br>With (Acceptable) | Instantaneous power failure/undervoltage (IPF), During deceleration at occurrence of power failure (retained until release) (Y46), Regenerative brake pre-alarm (RBP), DC current feeding (Y85), Main circuit capacitor life (Y87), Inrush current limit circuit life (Y89)<br>Without (Unacceptable) |
| **Pr.192 IPF terminal function selection** | Initial value "2" (IPF) | Initial value "9999" (No function) |
| **Inrush current limit circuit life display, Main circuit capacitor life display (Pr.256, Pr.258, Pr.259)** | With the parameter | Without the parameter |
| **Pr.599 X10 terminal input selection** | Initial value "0" (NO contact specification) | Initial value "1"(NC contact specification) |
| **Pr.872 Input phase loss protection selection** | With the parameter | Without the parameter |
| **Warning, protective functions** | Regenerative brake pre-alarm (RB), Instantaneous power failure (E.IPF), Undervoltage (E.UVT), Input phase loss (E.ILF), Brake transistor alarm detection (E.BE), Inrush current limit circuit fault (E.IOH)<br>Available | Regenerative brake pre-alarm (RB), Instantaneous power failure (E.IPF), Undervoltage (E.UVT), Input phase loss (E.ILF), Brake transistor alarm detection (E.BE), Inrush current limit circuit fault (E.IOH)<br>Not available |

# Appendix3 Instructions for compliance with the EU Directives

The EU Directives are issued to standardize different national regulations of the EU Member States and to facilitate free movement of the equipment, whose safety is ensured, in the EU territory.
Since 1996, compliance with the EMC Directive that is one of the EU Directives has been legally required. Since 1997, compliance with the Low Voltage Directive, another EU Directive, has been also legally required. When a manufacturer confirms its equipment to be compliant with the EMC Directive and the Low Voltage Directive, the manufacturer must declare the conformity and affix the CE marking.

- The authorized representative in the EU
  The authorized representative in the EU is shown below.
  Company name: Mitsubishi Electric Europe B.V.
  Address: Gothaer Strasse 8, 40880 Ratingen, Germany
- Note
  We declare that this inverter conforms with the EMC Directive in industrial environments and affix the CE marking on the inverter. When using the inverter in a residential area, take appropriate measures and ensure the conformity of the inverter used in the residential area.

## ◆EMC Directive

We declare that this inverter conforms with the EMC Directive and affix the CE marking on the inverter.

- EMC Directive 2004/108/EC
- Standard(s): EN61800-3:2004 (Second environment / PDS Category "C3")
- This inverter is not intended to be used on a low-voltage public network which supplies domestic premises.
- Radio frequency interference is expected if used on such a network.
- The installer shall provide a guide for installation and use, including recommended mitigation devices.

Note:
First environment
Environment including residential buildings. Includes building directly connected without a transformer to the low voltage power supply network which supplies power to residential buildings.
Second environment
Environment including all buildings except buildings directly connected without a transformer to the lower voltage power supply network which supplies power to residential buildings.

### ◆Note

Set the EMC filter valid and install the inverter and perform wiring according to the following instructions.

∗1 The converter unit is equipped with an EMC filter. Enable the EMC filter. (For details, refer to page 66.)
∗2 Connect the inverter and the converter unit to an earthed power supply.
∗3 Install a motor and a control cable written in the EMC Installation Manual (BCN-A21041-204) according to the instruction.
∗4 Confirm that the inverter and the converter unit conform with the EMC Directive as the industrial drives application for final installation.

# ◆Low Voltage Directive

We have self-confirmed our inverters as products compliant to the Low Voltage Directive (Conforming standard EN 61800-5-1) and affix the CE marking on the inverters.

## ◆Outline of instructions

∗1 Do not use an earth leakage current breaker as an electric shock protector without connecting the equipment to the earth. Connect the equipment to the earth (ground) securely.

∗2 Wire the earth terminal independently. (Do not connect two or more cables to one terminal.)

∗3 Use the cable sizes on **page 30** under the following conditions.
Surrounding air temperature 40°C (104°F) maximum
If conditions are different from above, select appropriate wire according to EN60204 Appendix C TABLE 5.

∗4 Use a tinned (plating should not include zinc) crimping terminal to connect the earth (ground) cable. When tightening the screw, be careful not to damage the threads.
For use as a product compliant with the Low Voltage Directive, use PVC cable whose size is indicated on **page 30**.

∗5 Use the molded case circuit breaker and magnetic contactor which conform to the EN or IEC Standard.

∗6 DC current may flow from the inverter to a protective earth (ground) conductor. When using a residual current device (RDC) or residual current monitor (RDM), connect a type B RCD or RCM to the power supply side.

∗7 Use the inverter under the conditions of overvoltage category II (usable regardless of the earth (ground) condition of the power supply), overvoltage category III (usable with the earthed-neutral system power supply, 400 V class only) and pollution degree 2 or lower specified in IEC664.
To use the inverter under the conditions of pollution degree 2, install it in the enclosure of IP2X or higher.
To use the inverter under the conditions of pollution degree 3, install it in the enclosure of IP54 or higher.

∗8 On the input and output of the inverter and the converter unit, use cables of the type and size set forth in EN60204 Appendix C.

∗9 The operating capacity of the relay outputs (terminal symbols A1, B1, C1, A2, B2, C2) should be 30 VDC, 0.3 A. (Relay output has basic isolation from the internal circuit of the inverter and the converter unit.)

∗10 Control circuit terminals on **page 24** are safely isolated from the main circuit.

∗11 Environment (For the detail, refer to **page 17**.)

| | During operation | In storage | During Transportation |
|---|---|---|---|
| Surrounding air temperature | -10 to +40°C | -20 to +65°C | -20 to +65°C |
| Ambient humidity | 95%RH or less | 95%RH or less | 95%RH or less |
| Maximum altitude | 2500 m | 2500 m | 10000 m |

## ◆Wiring protection

Class T, Class J, Class CC, or Class L fuse must be provided.

| FR-CC2-[ ] | H315K | H355K | H400K | H450K | H500K |
|---|---|---|---|---|---|
| Rated fuse voltage (V) | 500 V or more | | | | |
| Fuse maximum allowable rating (A) ∗1 | 1100 | 1200 | 1350 | 1500 | 1800 |

∗1 Maximum allowable rating by US National Electrical Code. Exact size must be chosen for each installation.

## ◆Short circuit ratings

Suitable For Use in A Circuit Capable of Delivering Not More Than 100 kA rms Symmetrical Amperes, 550 V or 600 V Maximum.

# Appendix4 Instructions for UL and cUL

(Standard to comply with: UL 508C, CSA C22.2 No.14)

## ◆ General Precaution

CAUTION - Risk of Electric Shock -
The bus capacitor discharge time is 10 minutes. Before starting wiring or inspection, switch power off, wait for more than 10 minutes, and check for residual voltage between terminal P/+ and N/- with a meter etc., to avoid a hazard of electrical shock.
ATTENTION - Risque de choc électrique -
La durée de décharge du condensateur de bus est de 10 minutes. Avant de commencer le câblage ou l'inspection, mettez l'appareil hors tension et attendez plus de 10 minutes.

## ◆ Installation

The FR-A802 inverters with the below types of converter unit have been approved as products for use in enclosure.
Design the enclosure so that the surrounding air temperature, humidity and ambience of the inverter will satisfy the above specifications. (Refer to page 17.)

### ◆ Wiring protection

For installation in the United States, Class T, Class J, Class CC, or Class L fuse must be provided, in accordance with the National Electrical Code and any applicable local codes.
For installation in Canada, Class T, Class J, Class CC, or Class L fuse must be provided, in accordance with the Canadian Electrical Code and any applicable local codes.

| FR-CC2-[ ] | H315K | H355K | H400K | H450K | H500K |
|---|---|---|---|---|---|
| Rated fuse voltage (V) | 500 V or more | | | | |
| Fuse maximum allowable rating (A) *1 | 1100 | 1200 | 1350 | 1500 | 1800 |

*1 Maximum allowable rating by US National Electrical Code. Exact size must be chosen for each installation.

## ◆ Wiring to the power supply and the motor

For wiring the input (R/L1, S/L2, T/L3) terminals of the converter unit and output (U, V, W) terminals of the inverter, use the UL listed copper, stranded wires (rated at 75°C) and round crimping terminals. Crimp the crimping terminals with the crimping tool recommended by the terminal maker.

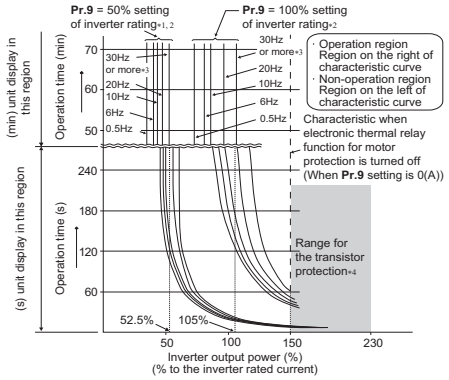
## ◆ Short circuit ratings

Suitable For Use in A Circuit Capable of Delivering Not More Than 100 kA rms Symmetrical Amperes, 550 V or 600 V Maximum.

## ◆ Motor overload protection

When using the electronic thermal relay function as motor overload protection, set the rated motor current in **Pr.9 Electronic thermal O/L relay**.

Operation characteristics of electronic thermal relay function




This function detects the overload (overheat) of the motor and trips the inverter by stopping the operation of the transistor at the inverter output side. (The operation characteristic is shown on the left.)

- Mitsubishi constant-torque motor

(1) Set one of "1", "13" to "16" in **Pr.71**. (This setting will enable the 100% constant-torque characteristic in the low-speed range.)
(2) Set the rated current of the motor in **Pr.9**.

*1 When a value 50% of the inverter rated output current (current value) is set in **Pr.9**
*2 The % value denotes the percentage to the rated inverter current. It is not the percentage to the rated motor current.
*3 When you set the electronic thermal relay function dedicated to the Mitsubishi constant-torque motor, this characteristic curve applies to operation at 6 Hz or higher.
*4 Transistor protection is activated depending on the temperature of the heatsink. The protection may be activated even with less than 150% depending on the operating conditions.

**NOTE**

- The internal accumulated heat value of the electronic thermal relay function is reset by inverter power reset and reset signal input. Avoid unnecessary reset and power-OFF.
- Install an external thermal relay (OCR) between the inverter and motors to operate several motors, a multi-pole motor or a dedicated motor with one inverter. Note that the current indicated on the motor rating plate is affected by the line-to-line leakage current (refer to Instruction Manual (Detailed)) when selecting the setting for an external thermal relay.
- The cooling effect of the motor drops during low-speed operation. Use a thermal protector or a motor with built-in thermistor.
- When the difference between the inverter and motor capacities is large and the setting is small, the protective characteristics of the electronic thermal relay function will be deteriorated. In such case, use an external thermal relay.
- A dedicated motor cannot be protected by an electronic thermal O/L relay. Use an external thermal relay.
- If the electronic thermal O/L relay is set to 5% or lower of the rated inverter current, the electronic thermal O/L relay may not operate.
- Motor over temperature sensing is not provided by the drive.

## ◆About the enclosed CD-ROM

The enclosed CD-ROM contains PDF copies of the manuals related to this product.

## ◆Before using the enclosed CD-ROM

- The copyright and other rights of the enclosed CD-ROM all belong to Mitsubishi Electric Corporation.
- No part of the enclosed CD-ROM may be copied or reproduced without the permission of Mitsubishi Electric Corporation.
- Specifications of the enclosed CD-ROM are subject to change for modification without notice.
- We are not responsible for any damages and lost earnings, etc. from use of the enclosed CD-ROM.
- Microsoft, Windows, Microsoft WindowsNT, Internet Explorer are registered trademarks of Microsoft Corporation in the United States and/or other countries.
  Adobe and Adobe Reader are registered trademarks of Adobe Systems Incorporated.
  Pentium is a registered trademark of Intel Corporation of the United States and/or other countries.
  Other company and product names herein are the trademarks and registered trademarks of their respective owners.
- Warranty
  We do not provide a warranty against defects in the enclosed CD-ROM and related documents.

NOTE

- This is a personal computer dedicated CD-ROM. Do not attempt to play it on ordinary audio devices. The loud volume may damage hearing and speakers.

## ◆When playing the enclosed CD-ROM on Windows OS

### ◆Operating environment

- The following system is required to read instruction manuals contained in the enclosed CD-ROM.

| Item | Specifications |
|---|---|
| OS | Microsoft Windows XP Professional or Home Edition,<br>Windows XP Tablet PC Edition, Windows vista, Windows 7, Windows 8 |
| CPU | Intel Pentium or better processor |
| Memory | 128 MB of RAM |
| Hard disk | 90 MB of available hard-disk space |
| CD-ROM drive | Double speed or more (more than quadruple speed is recommended) |
| Monitor | 800x600 dot or more |
| Application | Adobe Reader 7.0 or more<br>Internet Explorer 6.0 or more |

### ◆Operating method of the enclosed CD-ROM

- How to read instruction manuals
  Step 1. Start Windows and place the enclosed CD-ROM in the CD-ROM drive.
  Step 2. The main window automatically opens by the web browser.
  Step 3. Choose your language by a language choice menu of the page left edge.
  Step 4. Click a manual you want to read in the "INSTRUCTION MANUAL" list.
  Step 5. PDF manual you clicked opens.

- Manual opening of the enclosed CD-ROM
  Step 1. Start Windows and place the enclosed CD-ROM in the CD-ROM drive.
  Step 2. Select a CD-ROM drive (example: D drive) of "My computer" and click the right mouse button. Then, click "open" in the context menu.
  Step 3. Open "index.html" in the opened folder.
  Step 4. The main window opens by the web browser. Operates according to the steps from "Step 3" of "How to read instruction manuals"

- PDF data of the instruction manual are stored in "MANUAL" folder on the enclosed CD-ROM.

MEMO

REVISIONS

*The manual number is given on the bottom left of the back cover.

| Print Date | *Manual Number | Revision |
|---|---|---|
| Feb. 2014 | IB(NA)-0600534ENG-A | First edition |
| | | |

**⚠ For Maximum Safety**

- Mitsubishi inverters are not designed or manufactured to be used in equipment or systems in situations that can affect or endanger human life.
- When considering this product for operation in special applications such as machinery or systems used in passenger transportation, medical, aerospace, atomic power, electric power, or submarine repeating applications, please contact your nearest Mitsubishi sales representative.
- Although this product was manufactured under conditions of strict quality control, you are strongly advised to install safety devices to prevent serious accidents when it is used in facilities where breakdowns of the product are likely to cause a serious accident.
- Please do not use this product for loads other than three-phase induction motors.

MITSUBISHI ELECTRIC CORPORATION
HEAD OFFICE: TOKYO BUILDING 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

| Model | FR-A802 INSTRUCTION MANUAL (HARDWARE) |
|---|---|
| Model code | 1A2-P54 |

IB(NA)-0600534ENG-A(1402)MEE Printed in Japan

Specifications subject to change without notice.